Netflix_Movie_A18

June 5, 2019

1. Business Problem

1.1 Problem Description

Netflix is all about connecting people to the movies they love. To help customers find those movies, they developed world-class movie recommendation system: CinematchSM. Its job is to predict whether someone will enjoy a movie based on how much they liked or disliked other movies. Netflix use those predictions to make personal movie recommendations based on each customer's unique tastes. And while Cinematch is doing pretty well, it can always be made better.

Now there are a lot of interesting alternative approaches to how Cinematch works that netflix haven't tried. Some are described in the literature, some aren't. We're curious whether any of these can beat Cinematch by making better predictions. Because, frankly, if there is a much better approach it could make a big difference to our customers and our business.

Credits: https://www.netflixprize.com/rules.html

1.2 Problem Statement

Netflix provided a lot of anonymous rating data, and a prediction accuracy bar that is 10% better than what Cinematch can do on the same training data set. (Accuracy is a measurement of how closely predicted ratings of movies match subsequent actual ratings.)

1.3 Sources

https://www.netflixprize.com/rules.html

https://www.kaggle.com/netflix-inc/netflix-prize-data

Netflix blog: https://medium.com/netflix-techblog/netflix-recommendations-beyond-the-5-stars-part-1-55838468f429 (very nice blog)

surprise library: http://surpriselib.com/ (we use many models from this library)

surprise library doc: http://surprise.readthedocs.io/en/stable/getting_started.html (we use many models from this library)

installing surprise: https://github.com/NicolasHug/Surprise#installation

Research paper: http://courses.ischool.berkeley.edu/i290-dm/s11/SECURE/a1-koren.pdf (most of our work was inspired by this paper)

SVD Decomposition : https://www.youtube.com/watch?v=P5mlg91as1c

1.4 Real world/Business Objectives and constraints

Objectives: 1. Predict the rating that a user would give to a movie that he ahs not yet rated. 2. Minimize the difference between predicted and actual rating (RMSE and MAPE)

Constraints: 1. Some form of interpretability.

2. Machine Learning Problem

2.1 Data

2.1.1 Data Overview

Get the data from : https://www.kaggle.com/netflix-inc/netflix-prize-data/data
Data files :
combined_data_1.txt
combined_data_2.txt
combined_data_3.txt
combined_data_4.txt
movie_titles.csv
2.1.2 Example Data point
2.2 Mapping the real world problem to a Machine Learning Problem
2.2.1 Type of Machine Learning Problem
2.2.2 Performance metric
Mean Absolute Percentage Error: https://en.wikipedia.org/wiki/Mean_absolute_percentage_error
Root Mean Square Error: https://en.wikipedia.org/wiki/Root-mean-square_deviation
2.2.3 Machine Learning Objective and Constraints

1. Minimize RMSE.
2. Try to provide some interpretability.

In [0]:
```
# this is just to know how much time will it take to run this entire ipython notebook
from datetime import datetime
# globalstart = datetime.now()
import pandas as pd
import numpy as np
import matplotlib
matplotlib.use('nbagg')

import matplotlib.pyplot as plt
plt.rcParams.update({'figure.max_open_warning': 0})

import seaborn as sns
sns.set_style('whitegrid')
import os
from scipy import sparse
from scipy.sparse import csr_matrix

from sklearn.decomposition import TruncatedSVD
from sklearn.metrics.pairwise import cosine_similarity
import random
```

In [1]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

3. Exploratory Data Analysis

3.1 Preprocessing
3.1.1 Converting / Merging whole data to required format: u_i, m_j, r_ij

```
In [22]: start = datetime.now()

         if not os.path.isfile('drive//My Drive//data_folder//data.csv'):
             # Create a file 'data.csv' before reading it
             # Read all the files in netflix and store them in one big file('data.csv')
             # We re reading from each of the four files and appendig each rating to a global
             data = open('drive//My Drive//data_folder//data.csv', mode = 'w')

             row = list()
             files=['drive//My Drive//data_folder//combined_data_1.txt','drive//My Drive//data
                    'drive//My Drive//data_folder//combined_data_3.txt', 'drive//My Drive//data
             for file in files:
                 print("Reading ratings from {}...".format(file))
                 with open(file) as f:
                     for line in f:
                         del row[:] # you don't have to do this.
                         line = line.strip()
                         if line.endswith(':'):
                             # All below are ratings for this movie, until another movie appea
                             movie_id = line.replace(':', '')
                         else:
                             row = [x for x in line.split(',')]
                             row.insert(0, movie_id)
                             data.write(','.join(row))
                             data.write('\n')
                 print("Done.\n")
             data.close()
         print('Time taken :', datetime.now() - start)
```

```
Time taken : 0:00:00.001898
```

```
In [23]: print("creating the dataframe from data.csv file..")
         df = pd.read_csv('drive//My Drive//data_folder//data.csv', sep=',',
                                names=['movie', 'user','rating','date'])
         df.date = pd.to_datetime(df.date)
         print('Done.\n')

         # we are arranging the ratings according to time.
         print('Sorting the dataframe by date..')
         df.sort_values(by='date', inplace=True)
         print('Done..')
```

```
creating the dataframe from data.csv file..
Done.

Sorting the dataframe by date..
Done..
```

```
In [24]: df.head()
```

```
Out[24]:            movie    user  rating       date
         56431994  10341  510180       4 1999-11-11
         9056171    1798  510180       5 1999-11-11
         58698779  10774  510180       3 1999-11-11
         48101611   8651  510180       2 1999-11-11
         81893208  14660  510180       2 1999-11-11
```

```
In [25]: df.describe()['rating']
```

```
Out[25]: count    1.004805e+08
         mean     3.604290e+00
         std      1.085219e+00
         min      1.000000e+00
         25%      3.000000e+00
         50%      4.000000e+00
         75%      4.000000e+00
         max      5.000000e+00
         Name: rating, dtype: float64
```

3.1.2 Checking for NaN values

```
In [26]: # just to make sure that all Nan containing rows are deleted..
         print("No of Nan values in our dataframe : ", sum(df.isnull().any()))
```

```
No of Nan values in our dataframe :  0
```

3.1.3 Removing Duplicates

```
In [27]: dup_bool = df.duplicated(['movie','user','rating'])
         dups = sum(dup_bool) # by considering all columns..( including timestamp)
         print("There are {} duplicate rating entries in the data..".format(dups))
```

```
There are 0 duplicate rating entries in the data..
```

3.1.4 Basic Statistics (#Ratings, #Users, and #Movies)

```
In [28]: print("Total data ")
         print("-"*50)
         print("\nTotal no of ratings :",df.shape[0])
         print("Total No of Users   :", len(np.unique(df.user)))
         print("Total No of movies  :", len(np.unique(df.movie)))
```

```
Total data
--------------------------------------------------

Total no of ratings : 100480507
Total No of Users   : 480189
Total No of movies  : 17770
```

3.2 Spliting data into Train and Test(80:20)

```
In [0]: '''
        if not os.path.isfile('train.csv'):
            # create the dataframe and store it in the disk for offline purposes..
            df.iloc[:int(df.shape[0]*0.80)].to_csv("train.csv", index=False)

        if not os.path.isfile('test.csv'):
            # create the dataframe and store it in the disk for offline purposes..
            df.iloc[int(df.shape[0]*0.80):].to_csv("test.csv", index=False)
        '''
        train_df = pd.read_csv("drive//My Drive//data_folder//train.csv", parse_dates=['date']
        test_df = pd.read_csv("drive//My Drive//data_folder//test.csv")
```

3.2.1 Basic Statistics in Train data (#Ratings, #Users, and #Movies)

```
In [0]: # movies = train_df.movie.value_counts()
        # users = train_df.user.value_counts()
        print("Training data ")
        print("-"*50)
        print("\nTotal no of ratings :",train_df.shape[0])
        print("Total No of Users   :", len(np.unique(train_df.user)))
        print("Total No of movies  :", len(np.unique(train_df.movie)))
```

```
Training data
--------------------------------------------------

Total no of ratings : 80384405
Total No of Users   : 405041
Total No of movies  : 17424
```

3.2.2 Basic Statistics in Test data (#Ratings, #Users, and #Movies)

```
In [0]: print("Test data ")
        print("-"*50)
        print("\nTotal no of ratings :",test_df.shape[0])
        print("Total No of Users   :", len(np.unique(test_df.user)))
        print("Total No of movies  :", len(np.unique(test_df.movie)))
```

```
Test data
--------------------------------------------------

Total no of ratings : 20096102
Total No of Users   : 349312
Total No of movies  : 17757
```

3.3 Exploratory Data Analysis on Train data

In [0]:
```
# method to make y-axis more readable
def human(num, units = 'M'):
    units = units.lower()
    num = float(num)
    if units == 'k':
        return str(num/10**3) + " K"
    elif units == 'm':
        return str(num/10**6) + " M"
    elif units == 'b':
        return str(num/10**9) +  " B"
```

3.3.1 Distribution of ratings

In [0]:
```
fig, ax = plt.subplots()
plt.title('Distribution of ratings over Training dataset', fontsize=15)
sns.countplot(train_df.rating)
ax.set_yticklabels([human(item, 'M') for item in ax.get_yticks()])
ax.set_ylabel('No. of Ratings(Millions)')

plt.show()
```

```
<IPython.core.display.Javascript object>


<IPython.core.display.HTML object>
```

Add new column (week day) to the data set for analysis.

In [0]:
```
# It is used to skip the warning ''SettingWithCopyWarning''..
pd.options.mode.chained_assignment = None  # default='warn'

train_df['day_of_week'] = train_df.date.dt.weekday_name

train_df.tail()
```

Out[0]:

	movie	user	rating	date	day_of_week
80384400	12074	2033618	4	2005-08-08	Monday
80384401	862	1797061	3	2005-08-08	Monday
80384402	10986	1498715	5	2005-08-08	Monday
80384403	14861	500016	4	2005-08-08	Monday
80384404	5926	1044015	5	2005-08-08	Monday

3.3.2 Number of Ratings per a month

In [0]:
```
ax = train_df.resample('m', on='date')['rating'].count().plot()
ax.set_title('No of ratings per month (Training data)')
plt.xlabel('Month')
plt.ylabel('No of ratings(per month)')
ax.set_yticklabels([human(item, 'M') for item in ax.get_yticks()])
plt.show()
```

<IPython.core.display.Javascript object>

<IPython.core.display.HTML object>

3.3.3 Analysis on the Ratings given by user

```
In [0]: no_of_rated_movies_per_user = train_df.groupby(by='user')['rating'].count().sort_values

        no_of_rated_movies_per_user.head()
```

```
Out[0]: user
        305344     17112
        2439493    15896
        387418     15402
        1639792     9767
        1461435     9447
        Name: rating, dtype: int64
```

```
In [0]: fig = plt.figure(figsize=plt.figaspect(.5))

        ax1 = plt.subplot(121)
        sns.kdeplot(no_of_rated_movies_per_user, shade=True, ax=ax1)
        plt.xlabel('No of ratings by user')
        plt.title("PDF")

        ax2 = plt.subplot(122)
        sns.kdeplot(no_of_rated_movies_per_user, shade=True, cumulative=True,ax=ax2)
        plt.xlabel('No of ratings by user')
        plt.title('CDF')

        plt.show()
```

<IPython.core.display.Javascript object>

<IPython.core.display.HTML object>

```
In [0]: no_of_rated_movies_per_user.describe()
```

```
Out[0]: count    405041.000000
        mean        198.459921
        std         290.793238
        min           1.000000
        25%          34.000000
        50%          89.000000
        75%         245.000000
        max       17112.000000
        Name: rating, dtype: float64
```

There, is something interesting going on with the quantiles..

In [0]:
```
quantiles = no_of_rated_movies_per_user.quantile(np.arange(0,1.01,0.01), interpolation=
```

In [0]:
```
plt.title("Quantiles and their Values")
quantiles.plot()
# quantiles with 0.05 difference
plt.scatter(x=quantiles.index[::5], y=quantiles.values[::5], c='orange', label="quantil
# quantiles with 0.25 difference
plt.scatter(x=quantiles.index[::25], y=quantiles.values[::25], c='m', label = "quantile
plt.ylabel('No of ratings by user')
plt.xlabel('Value at the quantile')
plt.legend(loc='best')

# annotate the 25th, 50th, 75th and 100th percentile values....
for x,y in zip(quantiles.index[::25], quantiles[::25]):
    plt.annotate(s="({} , {})".format(x,y), xy=(x,y), xytext=(x-0.05, y+500)
                ,fontweight='bold')


plt.show()
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

In [0]:
```
quantiles[::5]
```

Out[0]:
```
0.00       1
0.05       7
0.10      15
0.15      21
0.20      27
0.25      34
0.30      41
0.35      50
0.40      60
0.45      73
0.50      89
0.55     109
0.60     133
0.65     163
0.70     199
0.75     245
0.80     307
0.85     392
0.90     520
```

```
0.95       749
1.00     17112
Name: rating, dtype: int64
```

how many ratings at the last 5% of all ratings??

```
In [0]: print('\n No of ratings at last 5 percentile : {}\n'.format(sum(no_of_rated_movies_per_
```

```
 No of ratings at last 5 percentile : 20305
```

3.3.4 Analysis of ratings of a movie given by a user

```
In [0]: no_of_ratings_per_movie = train_df.groupby(by='movie')['rating'].count().sort_values(as

        fig = plt.figure(figsize=plt.figaspect(.5))
        ax = plt.gca()
        plt.plot(no_of_ratings_per_movie.values)
        plt.title('# RATINGS per Movie')
        plt.xlabel('Movie')
        plt.ylabel('No of Users who rated a movie')
        ax.set_xticklabels([])

        plt.show()
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

- **It is very skewed.. just like nunmber of ratings given per user.**
  - There are some movies (which are very popular) which are rated by huge number of users.
  - But most of the movies(like 90%) got some hundereds of ratings.

3.3.5 Number of ratings on each day of the week

```
In [0]: fig, ax = plt.subplots()
        sns.countplot(x='day_of_week', data=train_df, ax=ax)
        plt.title('No of ratings on each day...')
        plt.ylabel('Total no of ratings')
        plt.xlabel('')
        ax.set_yticklabels([human(item, 'M') for item in ax.get_yticks()])
        plt.show()
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

```
In [0]: start = datetime.now()
        fig = plt.figure(figsize=plt.figaspect(.45))
        sns.boxplot(y='rating', x='day_of_week', data=train_df)
        plt.show()
        print(datetime.now() - start)
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

```
0:01:10.003761
```

```
In [0]: avg_week_df = train_df.groupby(by=['day_of_week'])['rating'].mean()
        print(" AVerage ratings")
        print("-"*30)
        print(avg_week_df)
        print("\n")
```

```
 AVerage ratings
------------------------------
day_of_week
Friday       3.585274
Monday       3.577250
Saturday     3.591791
Sunday       3.594144
Thursday     3.582463
Tuesday      3.574438
Wednesday    3.583751
Name: rating, dtype: float64
```

3.3.6 Creating sparse matrix from data frame

3.3.6.1 Creating sparse matrix from train data frame

```
In [7]: start = datetime.now()
        if os.path.isfile('drive/My Drive/data_folder/train_sparse_matrix.npz'):
            print("It is present in your pwd, getting it from disk....")
            # just get it from the disk instead of computing it
```

```
        train_sparse_matrix = sparse.load_npz('drive/My Drive/data_folder/train_sparse_mat
        print("DONE..")
    else:
        print("We are creating sparse_matrix from the dataframe..")
        # create sparse_matrix and store it for after usage.
        # csr_matrix(data_values, (row_index, col_index), shape_of_matrix)
        # It should be in such a way that, MATRIX[row, col] = data
        train_sparse_matrix = sparse.csr_matrix((train_df.rating.values, (train_df.user.va
                                                    train_df.movie.values)),)

        print('Done. It\'s shape is : (user, movie) : ',train_sparse_matrix.shape)
        print('Saving it into disk for furthur usage..')
        # save it into disk
        sparse.save_npz("train_sparse_matrix.npz", train_sparse_matrix)
        print('Done..\n')

    print(datetime.now() - start)
```

```
It is present in your pwd, getting it from disk...
DONE..
0:00:07.080869
```

The Sparsity of Train Sparse Matrix

```
In [0]: us,mv = train_sparse_matrix.shape
        elem = train_sparse_matrix.count_nonzero()

        print("Sparsity Of Train matrix : {} % ".format(  (1-(elem/(us*mv))) * 100) )
```

```
Sparsity Of Train matrix : 99.8292709259195 %
```

3.3.6.2 Creating sparse matrix from test data frame

```
In [8]: start = datetime.now()
        if os.path.isfile('drive/My Drive/data_folder/test_sparse_matrix.npz'):
            print("It is present in your pwd, getting it from disk....")
            # just get it from the disk instead of computing it
            test_sparse_matrix = sparse.load_npz('drive/My Drive/data_folder/test_sparse_matri
            print("DONE..")
        else:
            print("We are creating sparse_matrix from the dataframe..")
            # create sparse_matrix and store it for after usage.
            # csr_matrix(data_values, (row_index, col_index), shape_of_matrix)
            # It should be in such a way that, MATRIX[row, col] = data
            test_sparse_matrix = sparse.csr_matrix((test_df.rating.values, (test_df.user.value
                                                    test_df.movie.values)))
```

```
    print('Done. It\'s shape is : (user, movie) : ',test_sparse_matrix.shape)
    print('Saving it into disk for furthur usage..')
    # save it into disk
    sparse.save_npz("test_sparse_matrix.npz", test_sparse_matrix)
    print('Done..\n')

print(datetime.now() - start)
```

```
It is present in your pwd, getting it from disk...
DONE..
0:00:01.940068
```

The Sparsity of Test data Matrix

```
In [0]: us,mv = test_sparse_matrix.shape
        elem = test_sparse_matrix.count_nonzero()

        print("Sparsity Of Test matrix : {} % ".format(  (1-(elem/(us*mv))) * 100) )
```

```
Sparsity Of Test matrix : 99.95731772988694 %
```

3.3.7 Finding Global average of all movie ratings, Average rating per user, and Average rating per movie

```
In [0]: # get the user averages in dictionary (key: user_id/movie_id, value: avg rating)

        def get_average_ratings(sparse_matrix, of_users):

            # average ratings of user/axes
            ax = 1 if of_users else 0 # 1 - User axes,0 - Movie axes

            # ".A1" is for converting Column_Matrix to 1-D numpy array
            sum_of_ratings = sparse_matrix.sum(axis=ax).A1
            # Boolean matrix of ratings ( whether a user rated that movie or not)
            is_rated = sparse_matrix!=0
            # no of ratings that each user OR movie..
            no_of_ratings = is_rated.sum(axis=ax).A1

            # max_user  and max_movie ids in sparse matrix
            u,m = sparse_matrix.shape
            # creae a dictionary of users and their average ratigns..
            average_ratings = { i : sum_of_ratings[i]/no_of_ratings[i]
                                         for i in range(u if of_users else m)
                                            if no_of_ratings[i] !=0}

            # return that dictionary of average ratings
            return average_ratings
```

3.3.7.1 finding global average of all movie ratings

```
In [0]: train_averages = dict()
        # get the global average of ratings in our train set.
        train_global_average = train_sparse_matrix.sum()/train_sparse_matrix.count_nonzero()
        train_averages['global'] = train_global_average
        train_averages
```

```
Out[0]: {'global': 3.582890686321557}
```

3.3.7.2 finding average rating per user

```
In [0]: train_averages['user'] = get_average_ratings(train_sparse_matrix, of_users=True)
        print('\nAverage rating of user 10 :',train_averages['user'][10])
```

```

Average rating of user 10 : 3.3781094527363185
```

3.3.7.3 finding average rating per movie

```
In [0]: train_averages['movie'] =  get_average_ratings(train_sparse_matrix, of_users=False)
        print('\n AVerage rating of movie 15 :',train_averages['movie'][15])
```

```

 AVerage rating of movie 15 : 3.3038461538461537
```

3.3.7.4 PDF's & CDF's of Avg.Ratings of Users & Movies (In Train Data)

```
In [0]: start = datetime.now()
        # draw pdfs for average rating per user and average
        fig, (ax1, ax2) = plt.subplots(nrows=1, ncols=2, figsize=plt.figaspect(.5))
        fig.suptitle('Avg Ratings per User and per Movie', fontsize=15)

        ax1.set_title('Users-Avg-Ratings')
        # get the list of average user ratings from the averages dictionary..
        user_averages = [rat for rat in train_averages['user'].values()]
        sns.distplot(user_averages, ax=ax1, hist=False,
                     kde_kws=dict(cumulative=True), label='Cdf')
        sns.distplot(user_averages, ax=ax1, hist=False,label='Pdf')

        ax2.set_title('Movies-Avg-Rating')
        # get the list of movie_average_ratings from the dictionary..
        movie_averages = [rat for rat in train_averages['movie'].values()]
        sns.distplot(movie_averages, ax=ax2, hist=False,
                     kde_kws=dict(cumulative=True), label='Cdf')
        sns.distplot(movie_averages, ax=ax2, hist=False, label='Pdf')

        plt.show()
        print(datetime.now() - start)
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

```
0:00:35.003443
```

3.3.8 Cold Start problem

3.3.8.1 Cold Start problem with Users

```
In [0]: total_users = len(np.unique(df.user))
        users_train = len(train_averages['user'])
        new_users = total_users - users_train

        print('\nTotal number of Users  :', total_users)
        print('\nNumber of Users in Train data :', users_train)
        print("\nNo of Users that didn't appear in train data: {}({} %) \n ".format(new_users,
                                                                                np.round((new_u
```

```
Total number of Users  : 480189

Number of Users in Train data : 405041

No of Users that didn't appear in train data: 75148(15.65 %)
```

We might have to handle **new users** (***75148***) who didn't appear in train data.

3.3.8.2 Cold Start problem with Movies

```
In [0]: total_movies = len(np.unique(df.movie))
        movies_train = len(train_averages['movie'])
        new_movies = total_movies - movies_train

        print('\nTotal number of Movies  :', total_movies)
        print('\nNumber of Users in Train data :', movies_train)
        print("\nNo of Movies that didn't appear in train data: {}({} %) \n ".format(new_movies
                                                                                np.round((new_m
```

```
Total number of Movies  : 17770

Number of Users in Train data : 17424

No of Movies that didn't appear in train data: 346(1.95 %)
```

We might have to handle **346 movies** (small comparatively) in test data

3.4 Computing Similarity matrices

3.4.1 Computing User-User Similarity matrix

1. Calculating User User Similarity_Matrix is **not very easy**(*unless you have huge Computing Power and lots of time*) because of number of. usersbeing lare.

   - You can try if you want to. Your system could crash or the program stops with **Memory Error**

3.4.1.1 Trying with all dimensions (17k dimensions per user)

```
In [0]: from sklearn.metrics.pairwise import cosine_similarity


        def compute_user_similarity(sparse_matrix, compute_for_few=False, top = 100, verbose=Fa
                                    draw_time_taken=True):
            no_of_users, _ = sparse_matrix.shape
            # get the indices of  non zero rows(users) from our sparse matrix
            row_ind, col_ind = sparse_matrix.nonzero()
            row_ind = sorted(set(row_ind)) # we don't have to
            time_taken = list() #  time taken for finding similar users for an user..

            # we create rows, cols, and data lists.., which can be used to create sparse matri
            rows, cols, data = list(), list(), list()
            if verbose: print("Computing top",top,"similarities for each user..")

            start = datetime.now()
            temp = 0

            for row in row_ind[:top] if compute_for_few else row_ind:
                temp = temp+1
                prev = datetime.now()

                # get the similarity row for this user with all other users
                sim = cosine_similarity(sparse_matrix.getrow(row), sparse_matrix).ravel()
                # We will get only the top ''top'' most similar users and ignore rest of them.
                top_sim_ind = sim.argsort()[-top:]
                top_sim_val = sim[top_sim_ind]

                # add them to our rows, cols and data
                rows.extend([row]*top)
                cols.extend(top_sim_ind)
                data.extend(top_sim_val)
                time_taken.append(datetime.now().timestamp() - prev.timestamp())
                if verbose:
                    if temp%verb_for_n_rows == 0:
                        print("computing done for {} users [  time elapsed : {}  ]"
```

```
                                    .format(temp, datetime.now()-start))


            # lets create sparse matrix out of these and return it
            if verbose: print('Creating Sparse matrix from the computed similarities')
            #return rows, cols, data

            if draw_time_taken:
                plt.plot(time_taken, label = 'time taken for each user')
                plt.plot(np.cumsum(time_taken), label='Total time')
                plt.legend(loc='best')
                plt.xlabel('User')
                plt.ylabel('Time (seconds)')
                plt.show()

            return sparse.csr_matrix((data, (rows, cols)), shape=(no_of_users, no_of_users)), t
```

```
In [0]: start = datetime.now()
        u_u_sim_sparse, _ = compute_user_similarity(train_sparse_matrix, compute_for_few=True,
                                                              verbose=True)
        print("-"*100)
        print("Time taken :",datetime.now()-start)
```

```
Computing top 100 similarities for each user..
computing done for 20 users [  time elapsed : 0:03:20.300488  ]
computing done for 40 users [  time elapsed : 0:06:38.518391  ]
computing done for 60 users [  time elapsed : 0:09:53.143126  ]
computing done for 80 users [  time elapsed : 0:13:10.080447  ]
computing done for 100 users [  time elapsed : 0:16:24.711032  ]
Creating Sparse matrix from the computed similarities


<IPython.core.display.Javascript object>


<IPython.core.display.HTML object>


----------------------------------------------------------------------------------------------------
Time taken : 0:16:33.618931
```

3.4.1.2 Trying with reduced dimensions (Using TruncatedSVD for dimensionality reduction of user vector)

- We have **405,041 users** in out training set and computing similarities between them..(**17K dimensional vector..**) is time consuming..
- From above plot, It took roughly **8.88 sec** for computing simlilar users for **one user**

- We have **405,041 users** with us in training set.
- $405041 \times 8.88 = 3596764.08\,\text{sec} \quad = \quad 59946.068\,\text{min} \quad = \quad 999.101133333\,\text{hours} \quad =$ 41.629213889 days...
  - Even if we run on 4 cores parallelly (a typical system now a days), It will still take almost **10 and 1/2** days.

IDEA: Instead, we will try to reduce the dimentsions using SVD, so that **it might** speed up the process...

```
In [0]: from datetime import datetime
        from sklearn.decomposition import TruncatedSVD

        start = datetime.now()

        # initilaize the algorithm with some parameters..
        # All of them are default except n_components. n_itr is for Randomized SVD solver.
        netflix_svd = TruncatedSVD(n_components=500, algorithm='randomized', random_state=15)
        trunc_svd = netflix_svd.fit_transform(train_sparse_matrix)

        print(datetime.now()-start)
```

```
0:29:07.069783
```

Here,

- $\sum \longleftarrow$ (netflix_svd.**singular_values_**)
- $\bigvee^T \longleftarrow$ (netflix_svd.**components_**)
- $\bigcup$ is not returned. instead **Projection_of_X** onto the new vectorspace is returned.
- It uses **randomized svd** internally, which returns **All 3 of them saperately**. Use that instead..

```
In [0]: expl_var = np.cumsum(netflix_svd.explained_variance_ratio_)
```

```
In [0]: fig, (ax1, ax2) = plt.subplots(nrows=1, ncols=2, figsize=plt.figaspect(.5))

        ax1.set_ylabel("Variance Explained", fontsize=15)
        ax1.set_xlabel("# Latent Facors", fontsize=15)
        ax1.plot(expl_var)
        # annote some (latentfactors, expl_var) to make it clear
        ind = [1, 2,4,8,20, 60, 100, 200, 300, 400, 500]
        ax1.scatter(x = [i-1 for i in ind], y = expl_var[[i-1 for i in ind]], c='#ff3300')
        for i in ind:
            ax1.annotate(s ="({}, {})".format(i,  np.round(expl_var[i-1], 2)), xy=(i-1, expl_va
                        xytext = ( i+20, expl_var[i-1] - 0.01), fontweight='bold')
```

```
change_in_expl_var = [expl_var[i+1] - expl_var[i] for i in range(len(expl_var)-1)]
ax2.plot(change_in_expl_var)



ax2.set_ylabel("Gain in Var_Expl with One Additional LF", fontsize=10)
ax2.yaxis.set_label_position("right")
ax2.set_xlabel("# Latent Facors", fontsize=20)

plt.show()
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

```
In [0]: for i in ind:
            print("({}, {})".format(i, np.round(expl_var[i-1], 2)))
```

```
(1, 0.23)
(2, 0.26)
(4, 0.3)
(8, 0.34)
(20, 0.38)
(60, 0.44)
(100, 0.47)
(200, 0.53)
(300, 0.57)
(400, 0.61)
(500, 0.64)
```

I think 500 dimensions is good enough

- By just taking **(20 to 30)** latent factors, explained variance that we could get is **20 %**.
- To take it to **60%**, we have to take **almost 400 latent factors**. It is not fare.
- It basically is the **gain of variance explained**, if we ***add one additional latent factor to it.***
- By adding one by one latent factore too it, the _**gain in expained variance** with that addition is decreasing. (Obviously, because they are sorted that way).
- ***LHS Graph***:
  - **x** --- (No of latent factos),
  - **y** --- (The variance explained by taking x latent factors)

- **More decrease in the line (RHS graph)** :
    - We are getting more expained variance than before.
- **Less decrease in that line (RHS graph)** :
    - We are not getting benifitted from adding latent factor furthur. This is what is shown in the plots.
- ***RHS Graph***:
    - **x** --- (No of latent factors),
    - **y** --- (Gain n Expl_Var by taking one additional latent factor)

```
In [0]: # Let's project our Original U_M matrix into into 500 Dimensional space...
        start = datetime.now()
        trunc_matrix = train_sparse_matrix.dot(netflix_svd.components_.T)
        print(datetime.now()- start)
```

```
0:00:45.670265
```

```
In [0]: type(trunc_matrix), trunc_matrix.shape
```

```
Out[0]: (numpy.ndarray, (2649430, 500))
```

- Let's convert this to actual sparse matrix and store it for future purposes

```
In [0]: if not os.path.isfile('trunc_sparse_matrix.npz'):
            # create that sparse sparse matrix
            trunc_sparse_matrix = sparse.csr_matrix(trunc_matrix)
            # Save this truncated sparse matrix for later usage..
            sparse.save_npz('trunc_sparse_matrix', trunc_sparse_matrix)
        else:
            trunc_sparse_matrix = sparse.load_npz('trunc_sparse_matrix.npz')
```

```
In [0]: trunc_sparse_matrix.shape
```

```
Out[0]: (2649430, 500)
```

```
In [0]: start = datetime.now()
        trunc_u_u_sim_matrix, _ = compute_user_similarity(trunc_sparse_matrix, compute_for_few=
                                                     verb_for_n_rows=10)
        print("-"*50)
        print("time:",datetime.now()-start)
```

```
Computing top 50 similarities for each user..
computing done for 10 users [  time elapsed : 0:02:09.746324  ]
computing done for 20 users [  time elapsed : 0:04:16.017768  ]
computing done for 30 users [  time elapsed : 0:06:20.861163  ]
computing done for 40 users [  time elapsed : 0:08:24.933316  ]
computing done for 50 users [  time elapsed : 0:10:28.861485  ]
Creating Sparse matrix from the computed similarities
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

```
--------------------------------------------------
time: 0:10:52.658092
```

: This is taking more time for each user than Original one.

- from above plot, It took almost **12.18** for computing simlilar users for **one user**
- We have **405041 users** with us in training set.
- $405041 \times 12.18 ==== 4933399.38 \text{ sec} ==== 82223.323 \text{ min} ==== 1370.388716667 \text{ hours} ==== 57.099529861 \text{ days}...$
  - Even we run on 4 cores parallelly (a typical system now a days), It will still take almost **(14 - 15)** days.
- **Why did this happen...??**
  - Just think about it. It's not that difficult.

---------------------------------*(sparse & dense.................get it ??)*-----------------------------------

Is there any other way to compute user user similarity..??

-An alternative is to compute similar users for a particular user, whenenver required (**ie., Run time**) - We maintain a binary Vector for users, which tells us whether we already computed or not.. - ***If not*** : - Compute top (let's just say, 1000) most similar users for this given user, and add this to our datastructure, so that we can just access it(similar users) without recomputing it again. - - ***If It is already Computed***: - Just get it directly from our datastructure, which has that information. - In production time, We might have to recompute similarities, if it is computed a long time ago. Because user preferences changes over time. If we could maintain some kind of Timer, which when expires, we have to update it (recompute it). - - ***Which datastructure to use:*** - It is purely implementation dependant. - One simple method is to maintain a **Dictionary Of Dictionaries**. - - **key :** *userid* - **value**: *Again a dictionary* - **key** : *Similar User* - **value**: *Similarity Value*

3.4.2 Computing Movie-Movie Similarity matrix

```
In [0]: start = datetime.now()
        if not os.path.isfile('m_m_sim_sparse.npz'):
            print("It seems you don't have that file. Computing movie_movie similarity...")
            start = datetime.now()
            m_m_sim_sparse = cosine_similarity(X=train_sparse_matrix.T, dense_output=False)
            print("Done..")
            # store this sparse matrix in disk before using it. For future purposes.
            print("Saving it to disk without the need of re-computing it again.. ")
            sparse.save_npz("m_m_sim_sparse.npz", m_m_sim_sparse)
            print("Done..")
```

```python
else:
    print("It is there, We will get it.")
    m_m_sim_sparse = sparse.load_npz("m_m_sim_sparse.npz")
    print("Done ...")

print("It's a ",m_m_sim_sparse.shape," dimensional matrix")

print(datetime.now() - start)
```

```
It seems you don't have that file. Computing movie_movie similarity...
Done..
Saving it to disk without the need of re-computing it again..
Done..
It's a  (17771, 17771)  dimensional matrix
0:10:02.736054
```

In [0]:
```python
m_m_sim_sparse.shape
```

Out[0]:
```
(17771, 17771)
```

- Even though we have similarity measure of each movie, with all other movies, We generally don't care much about least similar movies.
- Most of the times, only top_xxx similar items matters. It may be 10 or 100.
- We take only those top similar movie ratings and store them in a saperate dictionary.

In [0]:
```python
movie_ids = np.unique(m_m_sim_sparse.nonzero()[1])
```

In [0]:
```python
start = datetime.now()
similar_movies = dict()
for movie in movie_ids:
    # get the top similar movies and store them in the dictionary
    sim_movies = m_m_sim_sparse[movie].toarray().ravel().argsort()[::-1][1:]
    similar_movies[movie] = sim_movies[:100]
print(datetime.now() - start)

# just testing similar movies for movie_15
similar_movies[15]
```

```
0:00:33.411700
```

Out[0]:
```
array([ 8279,  8013, 16528,  5927, 13105, 12049,  4424, 10193, 17590,
        4549,  3755,   590, 14059, 15144, 15054,  9584,  9071,  6349,
       16402,  3973,  1720,  5370, 16309,  9376,  6116,  4706,  2818,
         778, 15331,  1416, 12979, 17139, 17710,  5452,  2534,   164,
       15188,  8323,  2450, 16331,  9566, 15301, 13213, 14308, 15984,
       10597,  6426,  5500,  7068,  7328,  5720,  9802,   376, 13013,
```

```
 8003, 10199,  3338, 15390,  9688, 16455, 11730,  4513,   598,
12762,  2187,   509,  5865,  9166, 17115, 16334,  1942,  7282,
17584,  4376,  8988,  8873,  5921,  2716, 14679, 11947, 11981,
 4649,   565, 12954, 10788, 10220, 10963,  9427,  1690,  5107,
 7859,  5969,  1510,  2429,   847,  7845,  6410, 13931,  9840,
 3706])
```

3.4.3 Finding most similar movies using similarity matrix

__ Does Similarity really works as the way we expected...? __ *Let's pick some random movie and check for its similar movies....*

```
In [0]: # First Let's load the movie details into soe dataframe..
        # movie details are in 'netflix/movie_titles.csv'

        movie_titles = pd.read_csv("data_folder/movie_titles.csv", sep=',', header = None,
                                   names=['movie_id', 'year_of_release', 'title'], verbose=Tru
                              index_col = 'movie_id', encoding = "ISO-8859-1")

        movie_titles.head()
```

```
Tokenization took: 4.50 ms
Type conversion took: 165.72 ms
Parser memory cleanup took: 0.01 ms
```

Out[0]:

movie_id	year_of_release	title
1	2003.0	Dinosaur Planet
2	2004.0	Isle of Man TT 2004 Review
3	1997.0	Character
4	1994.0	Paula Abdul's Get Up & Dance
5	2004.0	The Rise and Fall of ECW

Similar Movies for 'Vampire Journals'

```
In [0]: mv_id = 67

        print("\nMovie ----->",movie_titles.loc[mv_id].values[1])

        print("\nIt has {} Ratings from users.".format(train_sparse_matrix[:,mv_id].getnnz()))

        print("\nWe have {} movies which are similarto this  and we will get only top most..".
```

```
Movie -----> Vampire Journals

It has 270 Ratings from users.

We have 17284 movies which are similarto this  and we will get only top most..
```

```
In [0]: similarities = m_m_sim_sparse[mv_id].toarray().ravel()

        similar_indices = similarities.argsort()[::-1][1:]

        similarities[similar_indices]

        sim_indices = similarities.argsort()[::-1][1:] # It will sort and reverse the array an
                                                       # and return its indices(movie_ids)
```

```
In [0]: plt.plot(similarities[sim_indices], label='All the ratings')
        plt.plot(similarities[sim_indices[:100]], label='top 100 similar movies')
        plt.title("Similar Movies of {}(movie_id)".format(mv_id), fontsize=20)
        plt.xlabel("Movies (Not Movie_Ids)", fontsize=15)
        plt.ylabel("Cosine Similarity",fontsize=15)
        plt.legend()
        plt.show()
```

```
<IPython.core.display.Javascript object>


<IPython.core.display.HTML object>
```

Top 10 similar movies

```
In [0]: movie_titles.loc[sim_indices[:10]]
```

```
Out[0]:           year_of_release                       title
        movie_id
        323                1999.0             Modern Vampires
        4044               1998.0   Subspecies 4: Bloodstorm
        1688               1993.0    To Sleep With a Vampire
        13962              2001.0   Dracula: The Dark Prince
        12053              1993.0             Dracula Rising
        16279              2002.0     Vampires: Los Muertos
        4667               1996.0                 Vampirella
        1900               1997.0               Club Vampire
        13873              2001.0                  The Breed
        15867              2003.0     Dracula II: Ascension
```

Similarly, we can ***find similar users*** and compare how similar they are.

4. Machine Learning Models

```
In [0]: def get_sample_sparse_matrix(sparse_matrix, no_users, no_movies, path, verbose = True)
            """
                It will get it from the ''path'' if it is present  or It will create
                and store the sampled sparse matrix in the path specified.
            """
```

```
        # get (row, col) and (rating) tuple from sparse_matrix...
        row_ind, col_ind, ratings = sparse.find(sparse_matrix)
        users = np.unique(row_ind)
        movies = np.unique(col_ind)

        print("Original Matrix : (users, movies) -- ({} {})".format(len(users), len(movies
        print("Original Matrix : Ratings -- {}\n".format(len(ratings)))

        # It just to make sure to get same sample everytime we run this program..
        # and pick without replacement....
        np.random.seed(15)
        sample_users = np.random.choice(users, no_users, replace=False)
        sample_movies = np.random.choice(movies, no_movies, replace=False)
        # get the boolean mask or these sampled_items in originl row/col_inds..
        mask = np.logical_and( np.isin(row_ind, sample_users),
                          np.isin(col_ind, sample_movies) )

        sample_sparse_matrix = sparse.csr_matrix((ratings[mask], (row_ind[mask], col_ind[ma
                                                 shape=(max(sample_users)+1, max(sample_mov

        if verbose:
            print("Sampled Matrix : (users, movies) -- ({} {})".format(len(sample_users), l
            print("Sampled Matrix : Ratings --", format(ratings[mask].shape[0]))

       # print('Saving it into disk for furthur usage..')
        # save it into disk
        #sparse.save_npz(path, sample_sparse_matrix)
        if verbose:
                print('Done..\n')

        return sample_sparse_matrix
```

4.1 Sampling Data

4.1.1 Build sample train data from the train data

```
In [12]: start = datetime.now()
         path = "drive/My Drive/data_folder/sample_train_sparse_matrix30k.npz"
         if os.path.isfile(path):
             print("It is present in your pwd, getting it from disk....")
             # just get it from the disk instead of computing it
             sample_train_sparse_matrix = sparse.load_npz(path)
             print("DONE..")
         else:
             # get 25k users and 3k movies from available data
             sample_train_sparse_matrix30k = get_sample_sparse_matrix(train_sparse_matrix, no_u
                                                      path = path)

         print(datetime.now() - start)
```

```
Original Matrix : (users, movies) -- (405041 17424)
Original Matrix : Ratings -- 80384405

Sampled Matrix : (users, movies) -- (25000 3000)
Sampled Matrix : Ratings -- 856986
Done..

0:01:26.948056
```

4.1.2 Build sample test data from the test data

In [13]:
```
start = datetime.now()

path = "drive/My Drive/data_folder/sample_test_sparse_matrix30k.npz"
if os.path.isfile(path):
    print("It is present in your pwd, getting it from disk....")
    # just get it from the disk instead of computing it
    sample_test_sparse_matrix = sparse.load_npz(path)
    print("DONE..")
else:
    # get 5k users and 500 movies from available data
    sample_test_sparse_matrix = get_sample_sparse_matrix(test_sparse_matrix, no_users=
                                                         path = path)
print(datetime.now() - start)
```

```
Original Matrix : (users, movies) -- (349312 17757)
Original Matrix : Ratings -- 20096102

Sampled Matrix : (users, movies) -- (5000 500)
Sampled Matrix : Ratings -- 7333
Done..

0:00:17.543704
```

4.2 Finding Global Average of all movie ratings, Average rating per User, and Average rating per Movie (from sampled train)

In [0]:
```
sample_train_averages = dict()
```

4.2.1 Finding Global Average of all movie ratings

In [16]:
```
# get the global average of ratings in our train set.
global_average = sample_train_sparse_matrix30k.sum()/sample_train_sparse_matrix30k.cou
sample_train_averages['global'] = global_average
sample_train_averages
```

Out[16]:
```
{'global': 3.5875813607223455}
```

4.2.2 Finding Average rating per User

```
In [19]: sample_train_averages['user'] = get_average_ratings(sample_train_sparse_matrix30k, of_
         print('\nAverage rating of user 1515220 :',sample_train_averages['user'][1515220])
```

```
Average rating of user 1515220 : 3.923076923076923
```

4.2.3 Finding Average rating per Movie

```
In [20]: sample_train_averages['movie'] =  get_average_ratings(sample_train_sparse_matrix30k, o
         print('\n AVerage rating of movie 15153 :',sample_train_averages['movie'][15153])
```

```
 AVerage rating of movie 15153 : 2.752
```

4.3 Featurizing data

```
In [23]: print('\n No of ratings in Our Sampled train matrix is : {}\n'.format(sample_train_spa
         print('\n No of ratings in Our Sampled test  matrix is : {}\n'.format(sample_test_spar
```

```
 No of ratings in Our Sampled train matrix is : 856986


 No of ratings in Our Sampled test  matrix is : 7333
```

4.3.1 Featurizing data for regression problem
4.3.1.1 Featurizing train data

```
In [0]: # get users, movies and ratings from our samples train sparse matrix
        sample_train_users, sample_train_movies, sample_train_ratings = sparse.find(sample_trai
```

```
In [0]: ############################################################
        # It took me almost 10 hours to prepare this train dataset.#
        ############################################################
        start = datetime.now()
        if os.path.isfile('sample/small/reg_train.csv'):
            print("File already exists you don't have to prepare again..." )
        else:
            print('preparing {} tuples for the dataset..\n'.format(len(sample_train_ratings)))
            with open('sample/small/reg_train.csv', mode='w') as reg_data_file:
                count = 0
                for (user, movie, rating)  in zip(sample_train_users, sample_train_movies, samp
                    st = datetime.now()
                #     print(user, movie)
```

```
    #--------------------- Ratings of "movie" by similar users of "user" -----
    # compute the similar Users of the "user"
    user_sim = cosine_similarity(sample_train_sparse_matrix[user], sample_trai
    top_sim_users = user_sim.argsort()[::-1][1:] # we are ignoring 'The User'
    # get the ratings of most similar users for this movie
    top_ratings = sample_train_sparse_matrix[top_sim_users, movie].toarray().ra
    # we will make it's length "5" by adding movie averages to .
    top_sim_users_ratings = list(top_ratings[top_ratings != 0][:5])
    top_sim_users_ratings.extend([sample_train_averages['movie'][movie]]*(5 - l
#     print(top_sim_users_ratings, end=" ")


    #--------------------- Ratings by "user"  to similar movies of "movie" ---
    # compute the similar movies of the "movie"
    movie_sim = cosine_similarity(sample_train_sparse_matrix[:,movie].T, sample
    top_sim_movies = movie_sim.argsort()[::-1][1:] # we are ignoring 'The User
    # get the ratings of most similar movie rated by this user..
    top_ratings = sample_train_sparse_matrix[user, top_sim_movies].toarray().ra
    # we will make it's length "5" by adding user averages to.
    top_sim_movies_ratings = list(top_ratings[top_ratings != 0][:5])
    top_sim_movies_ratings.extend([sample_train_averages['user'][user]]*(5-len
#     print(top_sim_movies_ratings, end=" : -- ")

    #-----------------prepare the row to be stores in a file-----------------#
    row = list()
    row.append(user)
    row.append(movie)
    # Now add the other features to this data...
    row.append(sample_train_averages['global']) # first feature
    # next 5 features are similar_users "movie" ratings
    row.extend(top_sim_users_ratings)
    # next 5 features are "user" ratings for similar_movies
    row.extend(top_sim_movies_ratings)
    # Avg_user rating
    row.append(sample_train_averages['user'][user])
    # Avg_movie rating
    row.append(sample_train_averages['movie'][movie])

    # finalley, The actual Rating of this user-movie pair...
    row.append(rating)
    count = count + 1

    # add rows to the file opened..
    reg_data_file.write(','.join(map(str, row)))
    reg_data_file.write('\n')
    if (count)%10000 == 0:
        # print(','.join(map(str, row)))
        print("Done for {} rows----- {}".format(count, datetime.now() - start)
```

```
    print(datetime.now() - start)
```

```
preparing 129286 tuples for the dataset..

Done for 10000 rows----- 0:53:13.974716
Done for 20000 rows----- 1:47:58.228942
Done for 30000 rows----- 2:42:46.963119
Done for 40000 rows----- 3:36:44.807894
Done for 50000 rows----- 4:28:55.311500
Done for 60000 rows----- 5:24:18.493104
Done for 70000 rows----- 6:17:39.669922
Done for 80000 rows----- 7:11:23.970879
Done for 90000 rows----- 8:05:33.787770
Done for 100000 rows----- 9:00:25.463562
Done for 110000 rows----- 9:51:28.530010
Done for 120000 rows----- 10:42:05.382141
11:30:13.699183
```

Reading from the file to make a Train_dataframe

In [25]:
```
reg_train = pd.read_csv('drive/My Drive/data_folder/reg_train.csv', names = ['user',
reg_train.head()
```

Out[25]:

	user	movie	GAvg	sur1	sur2	...	smr4	smr5	UAvg	MAvg	rating
0	53406	33	3.581679	4.0	5.0	...	3.0	1.0	3.370370	4.092437	4
1	99540	33	3.581679	5.0	5.0	...	3.0	5.0	3.555556	4.092437	3
2	99865	33	3.581679	5.0	5.0	...	5.0	4.0	3.714286	4.092437	5
3	101620	33	3.581679	2.0	3.0	...	4.0	5.0	3.584416	4.092437	5
4	112974	33	3.581679	5.0	5.0	...	5.0	3.0	3.750000	4.092437	5

[5 rows x 16 columns]

- **GAvg** : Average rating of all the ratings
- **Similar users rating of this movie**:
  - sur1, sur2, sur3, sur4, sur5 (top 5 similar users who rated that movie..)
- **Similar movies rated by this user**:
  - smr1, smr2, smr3, smr4, smr5 (top 5 similar movies rated by this movie..)
- **UAvg** : User's Average rating
- **MAvg** : Average rating of this movie

- **rating** : Rating of this movie by this user.

4.3.1.2 Featurizing test data

```
In [0]: # get users, movies and ratings from the Sampled Test
        sample_test_users, sample_test_movies, sample_test_ratings = sparse.find(sample_test_sp
```

```
In [27]: sample_train_averages['global']
```

```
Out[27]: 3.5875813607223455
```

```
In [0]: start = datetime.now()

        if os.path.isfile('drive/My Drive/data_folder/reg_test.csv'):
            print("It is already created...")
        else:

            print('preparing {} tuples for the dataset..\n'.format(len(sample_test_ratings)))
            with open('sample/small/reg_test.csv', mode='w') as reg_data_file:
                count = 0
                for (user, movie, rating)  in zip(sample_test_users, sample_test_movies, sample
                    st = datetime.now()

                #--------------------- Ratings of "movie" by similar users of "user" ---------
                    #print(user, movie)
                    try:
                        # compute the similar Users of the "user"
                        user_sim = cosine_similarity(sample_train_sparse_matrix[user], sample_t
                        top_sim_users = user_sim.argsort()[::-1][1:] # we are ignoring 'The Us
                        # get the ratings of most similar users for this movie
                        top_ratings = sample_train_sparse_matrix[top_sim_users, movie].toarray
                        # we will make it's length "5" by adding movie averages to .
                        top_sim_users_ratings = list(top_ratings[top_ratings != 0][:5])
                        top_sim_users_ratings.extend([sample_train_averages['movie'][movie]]*(5
                        # print(top_sim_users_ratings, end="--")

                    except (IndexError, KeyError):
                        # It is a new User or new Movie or there are no ratings for given user
                        ########## Cold STart Problem ##########
                        top_sim_users_ratings.extend([sample_train_averages['global']]*(5 - len
                        #print(top_sim_users_ratings)
                    except:
                        print(user, movie)
                        # we just want KeyErrors to be resolved. Not every Exception...
                        raise
```

```python
#--------------------- Ratings by "user"  to similar movies of "movie" ---
try:
    # compute the similar movies of the "movie"
    movie_sim = cosine_similarity(sample_train_sparse_matrix[:,movie].T, sa
    top_sim_movies = movie_sim.argsort()[::-1][1:] # we are ignoring 'The 
    # get the ratings of most similar movie rated by this user..
    top_ratings = sample_train_sparse_matrix[user, top_sim_movies].toarray
    # we will make it's length "5" by adding user averages to.
    top_sim_movies_ratings = list(top_ratings[top_ratings != 0][:5])
    top_sim_movies_ratings.extend([sample_train_averages['user'][user]]*(5
    #print(top_sim_movies_ratings)
except (IndexError, KeyError):
    #print(top_sim_movies_ratings, end=" : -- ")
    top_sim_movies_ratings.extend([sample_train_averages['global']]*(5-len
    #print(top_sim_movies_ratings)
except :
    raise

#-----------------prepare the row to be stores in a file-----------------#
row = list()
# add usser and movie name first
row.append(user)
row.append(movie)
row.append(sample_train_averages['global']) # first feature
#print(row)
# next 5 features are similar_users "movie" ratings
row.extend(top_sim_users_ratings)
#print(row)
# next 5 features are "user" ratings for similar_movies
row.extend(top_sim_movies_ratings)
#print(row)
# Avg_user rating
try:
    row.append(sample_train_averages['user'][user])
except KeyError:
    row.append(sample_train_averages['global'])
except:
    raise
#print(row)
# Avg_movie rating
try:
    row.append(sample_train_averages['movie'][movie])
except KeyError:
    row.append(sample_train_averages['global'])
except:
    raise
#print(row)
```

```
                # finalley, The actual Rating of this user-movie pair...
                row.append(rating)
                #print(row)
                count = count + 1

                # add rows to the file opened..
                reg_data_file.write(','.join(map(str, row)))
                #print(','.join(map(str, row)))
                reg_data_file.write('\n')
                if (count)%1000 == 0:
                    #print(','.join(map(str, row)))
                    print("Done for {} rows----- {}".format(count, datetime.now() - start)
        print("",datetime.now() - start)
```

```
preparing 7333 tuples for the dataset..

Done for 1000 rows----- 0:04:29.293783
Done for 2000 rows----- 0:08:57.208002
Done for 3000 rows----- 0:13:30.333223
Done for 4000 rows----- 0:18:04.050813
Done for 5000 rows----- 0:22:38.671673
Done for 6000 rows----- 0:27:09.697009
Done for 7000 rows----- 0:31:41.933568
 0:33:12.529731
```

Reading from the file to make a test dataframe

```
In [28]: reg_test_df = pd.read_csv('drive/My Drive/data_folder/reg_test.csv', names = ['user',
                                                                  'smr1', 'smr2', 'smr3', 'sm
                                                                  'UAvg', 'MAvg', 'rating'], 
         reg_test_df.head(4)
```

```
Out[28]:       user  movie      GAvg      sur1  ...      smr5      UAvg      MAvg  rating
         0   808635     71  3.581679  3.581679  ...  3.581679  3.581679  3.581679       5
         1   941866     71  3.581679  3.581679  ...  3.581679  3.581679  3.581679       4
         2  1737912     71  3.581679  3.581679  ...  3.581679  3.581679  3.581679       3
         3  1849204     71  3.581679  3.581679  ...  3.581679  3.581679  3.581679       4

         [4 rows x 16 columns]
```

- **GAvg** : Average rating of all the ratings
- **Similar users rating of this movie**:
  - sur1, sur2, sur3, sur4, sur5 (top 5 simiular users who rated that movie..)
- **Similar movies rated by this user**:

- smr1, smr2, smr3, smr4, smr5 (top 5 simiular movies rated by this movie..)

- **UAvg** : User AVerage rating
- **MAvg** : Average rating of this movie
- **rating** : Rating of this movie by this user.

```
In [30]: !pip install surprise
```

```
Collecting surprise
  Downloading https://files.pythonhosted.org/packages/61/de/e5cba8682201fcf9c3719a6fdda95693468
Collecting scikit-surprise (from surprise)
  Downloading https://files.pythonhosted.org/packages/4d/fc/cd4210b247d1dca421c25994740cbbf03c5
     || 3.3MB 4.9MB/s
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.6/dist-packages (from sci
Requirement already satisfied: numpy>=1.11.2 in /usr/local/lib/python3.6/dist-packages (from sc
Requirement already satisfied: scipy>=1.0.0 in /usr/local/lib/python3.6/dist-packages (from sci
Requirement already satisfied: six>=1.10.0 in /usr/local/lib/python3.6/dist-packages (from scil
Building wheels for collected packages: scikit-surprise
  Building wheel for scikit-surprise (setup.py) ... done
  Stored in directory: /root/.cache/pip/wheels/ec/c0/55/3a28eab06b53c220015063ebbdb81213cd3dcb
Successfully built scikit-surprise
Installing collected packages: scikit-surprise, surprise
Successfully installed scikit-surprise-1.0.6 surprise-0.1
```

4.3.2 Transforming data for Surprise models

```
In [0]: from surprise import Reader, Dataset
```

4.3.2.1 Transforming train data

- We can't give raw data (movie, user, rating) to train the model in Surprise library.
- They have a saperate format for TRAIN and TEST data, which will be useful for training the models like SVD, KNNBaseLineOnly....etc..,in Surprise.
- We can form the trainset from a file, or from a Pandas DataFrame. http://surprise.readthedocs.io/en/stable/getting_started.html#load-dom-dataframe-py

```
In [0]: # It is to specify how to read the dataframe.
        # for our dataframe, we don't have to specify anything extra..
        reader = Reader(rating_scale=(1,5))

        # create the traindata from the dataframe...
        train_data = Dataset.load_from_df(reg_train[['user', 'movie', 'rating']], reader)

        # build the trainset from traindata.., It is of dataset format from surprise library..
        trainset = train_data.build_full_trainset()
```

4.3.2.2 Transforming test data

- Testset is just a list of (user, movie, rating) tuples. (Order in the tuple is impotant)

In [33]:
```
testset = list(zip(reg_test_df.user.values, reg_test_df.movie.values, reg_test_df.rati
testset[:3]
```

Out[33]:
```
[(808635, 71, 5), (941866, 71, 4), (1737912, 71, 3)]
```

4.4 Applying Machine Learning models

- Global dictionary that stores rmse and mape for all the models....
  - It stores the metrics in a dictionary of dictionaries

    keys : model names(string)

    value: dict(**key** : metric, **value** : value)

In [34]:
```
models_evaluation_train = dict()
models_evaluation_test = dict()

models_evaluation_train, models_evaluation_test
```

Out[34]:
```
({}, {})
```

Utility functions for running regression models

In [0]:
```
# to get rmse and mape given actual and predicted ratings..
def get_error_metrics(y_true, y_pred):
    rmse = np.sqrt(np.mean([ (y_true[i] - y_pred[i])**2 for i in range(len(y_pred)) ]))
    mape = np.mean(np.abs( (y_true - y_pred)/y_true )) * 100
    return rmse, mape

###################################################################
###################################################################
def run_xgboost(algo,  x_train, y_train, x_test, y_test, verbose=True):
    """
    It will return train_results and test_results
    """

    # dictionaries for storing train and test results
    train_results = dict()
    test_results = dict()


    # fit the model
    print('Training the model..')
    start =datetime.now()
    algo.fit(x_train, y_train, eval_metric = 'rmse')
```

```
        print('Done. Time taken : {}\n'.format(datetime.now()-start))
        print('Done \n')

        # from the trained model, get the predictions....
        print('Evaluating the model with TRAIN data...')
        start =datetime.now()
        y_train_pred = algo.predict(x_train)
        # get the rmse and mape of train data...
        rmse_train, mape_train = get_error_metrics(y_train.values, y_train_pred)

        # store the results in train_results dictionary..
        train_results = {'rmse': rmse_train,
                         'mape' : mape_train,
                         'predictions' : y_train_pred}

        #######################################
        # get the test data predictions and compute rmse and mape
        print('Evaluating Test data')
        y_test_pred = algo.predict(x_test)
        rmse_test, mape_test = get_error_metrics(y_true=y_test.values, y_pred=y_test_pred)
        # store them in our test results dictionary.
        test_results = {'rmse': rmse_test,
                         'mape' : mape_test,
                         'predictions':y_test_pred}
        if verbose:
            print('\nTEST DATA')
            print('-'*30)
            print('RMSE : ', rmse_test)
            print('MAPE : ', mape_test)

        # return these train and test results...
        return train_results, test_results
```

Utility functions for Surprise modes

In [0]:
```
# it is just to makesure that all of our algorithms should produce same results
# everytime they run...

my_seed = 15
random.seed(my_seed)
np.random.seed(my_seed)

##########################################################
# get  (actual_list , predicted_list) ratings given list
# of predictions (prediction is a class in Surprise).
##########################################################
def get_ratings(predictions):
```

```
    actual = np.array([pred.r_ui for pred in predictions])
    pred = np.array([pred.est for pred in predictions])

    return actual, pred

################################################################
# get ''rmse'' and ''mape'' , given list of prediction objecs
################################################################
def get_errors(predictions, print_them=False):

    actual, pred = get_ratings(predictions)
    rmse = np.sqrt(np.mean((pred - actual)**2))
    mape = np.mean(np.abs(pred - actual)/actual)

    return rmse, mape*100

##################################################################################
# It will return predicted ratings, rmse and mape of both train and test data   #
##################################################################################
def run_surprise(algo, trainset, testset, verbose=True):
    '''
        return train_dict, test_dict

        It returns two dictionaries, one for train and the other is for test
        Each of them have 3 key-value pairs, which specify ''rmse'', ''mape'', and ''p
    '''
    start = datetime.now()
    # dictionaries that stores metrics for train and test..
    train = dict()
    test = dict()

    # train the algorithm with the trainset
    st = datetime.now()
    print('Training the model...')
    algo.fit(trainset)
    print('Done. time taken : {} \n'.format(datetime.now()-st))

    # ---------------- Evaluating train data--------------------#
    st = datetime.now()
    print('Evaluating the model with train data..')
    # get the train predictions (list of prediction class inside Surprise)
    train_preds = algo.test(trainset.build_testset())
    # get predicted ratings from the train predictions..
    train_actual_ratings, train_pred_ratings = get_ratings(train_preds)
    # get ''rmse'' and ''mape'' from the train predictions.
    train_rmse, train_mape = get_errors(train_preds)
    print('time taken : {}'.format(datetime.now()-st))
```

```
        if verbose:
            print('-'*15)
            print('Train Data')
            print('-'*15)
            print("RMSE : {}\n\nMAPE : {}\n".format(train_rmse, train_mape))

        #store them in the train dictionary
        if verbose:
            print('adding train results in the dictionary..')
        train['rmse'] = train_rmse
        train['mape'] = train_mape
        train['predictions'] = train_pred_ratings

        #------------ Evaluating Test data---------------#
        st = datetime.now()
        print('\nEvaluating for test data...')
        # get the predictions( list of prediction classes) of test data
        test_preds = algo.test(testset)
        # get the predicted ratings from the list of predictions
        test_actual_ratings, test_pred_ratings = get_ratings(test_preds)
        # get error metrics from the predicted and actual ratings
        test_rmse, test_mape = get_errors(test_preds)
        print('time taken : {}'.format(datetime.now()-st))

        if verbose:
            print('-'*15)
            print('Test Data')
            print('-'*15)
            print("RMSE : {}\n\nMAPE : {}\n".format(test_rmse, test_mape))
        # store them in test dictionary
        if verbose:
            print('storing the test results in test dictionary...')
        test['rmse'] = test_rmse
        test['mape'] = test_mape
        test['predictions'] = test_pred_ratings

        print('\n'+'-'*45)
        print('Total time taken to run this algorithm :', datetime.now() - start)

        # return two dictionaries train and test
        return train, test
```

4.4.1 XGBoost with initial 13 features

In [0]:
```
import xgboost as xgb
```

In [0]:
```
x_train = reg_train.drop(['user','movie','rating'], axis=1)
y_train = reg_train['rating']
```

```
# Prepare Test data
x_test = reg_test_df.drop(['user','movie','rating'], axis=1)
y_test = reg_test_df['rating']
```

In [0]:
```
# prepare Train data
from sklearn.model_selection import RandomizedSearchCV

param_grid ={'max_depth': list(range(3,10,2)),'learning_rate':[0.001,0.01,0.1,1.0]}
# initialize Our first XGBoost model...
first_xgb = RandomizedSearchCV(xgb.XGBRegressor(silent=False, n_jobs=-1, random_state=
```

In [54]:
```
train_results, test_results = run_xgboost(first_xgb, x_train, y_train, x_test, y_test

 # store the results in models_evaluations dictionaries
 models_evaluation_train['first_algo'] = train_results
 models_evaluation_test['first_algo'] = test_results
```

```
Training the model..
Fitting 3 folds for each of 10 candidates, totalling 30 fits
[CV] max_depth=5, learning_rate=0.01 ...
[06:39:30] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecat


/usr/local/lib/python3.6/dist-packages/sklearn/model_selection/_split.py:1978: FutureWarning: 
  warnings.warn(CV_WARNING, FutureWarning)
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depr
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=5, learning_rate=0.01, total=   6.4s
[CV] max_depth=5, learning_rate=0.01 ...
[06:39:37] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecat


[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    6.4s remaining:    0.0s
/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depr
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=5, learning_rate=0.01, total=   6.7s
[CV] max_depth=5, learning_rate=0.01 ...
[06:39:43] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecat


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depr
  if getattr(data, 'base', None) is not None and \
```

```
[CV] ... max_depth=5, learning_rate=0.01, total=   6.6s
[CV] max_depth=9, learning_rate=0.1 ...
[06:39:50] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=9, learning_rate=0.1, total=  14.4s
[CV] max_depth=9, learning_rate=0.1 ...
[06:40:04] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=9, learning_rate=0.1, total=  14.2s
[CV] max_depth=9, learning_rate=0.1 ...
[06:40:18] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=9, learning_rate=0.1, total=  14.2s
[CV] max_depth=7, learning_rate=0.001 ...
[06:40:33] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=7, learning_rate=0.001, total=   9.6s
[CV] max_depth=7, learning_rate=0.001 ...
[06:40:42] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=7, learning_rate=0.001, total=   9.8s
[CV] max_depth=7, learning_rate=0.001 ...
[06:40:52] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate
```

```
/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=7, learning_rate=0.001, total=   9.6s
[CV] max_depth=5, learning_rate=0.001 ...
[06:41:02] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=5, learning_rate=0.001, total=   6.1s
[CV] max_depth=5, learning_rate=0.001 ...
[06:41:08] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=5, learning_rate=0.001, total=   6.2s
[CV] max_depth=5, learning_rate=0.001 ...
[06:41:14] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=5, learning_rate=0.001, total=   6.2s
[CV] max_depth=5, learning_rate=0.1 ...
[06:41:20] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=5, learning_rate=0.1, total=   6.8s
[CV] max_depth=5, learning_rate=0.1 ...
[06:41:27] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \
```

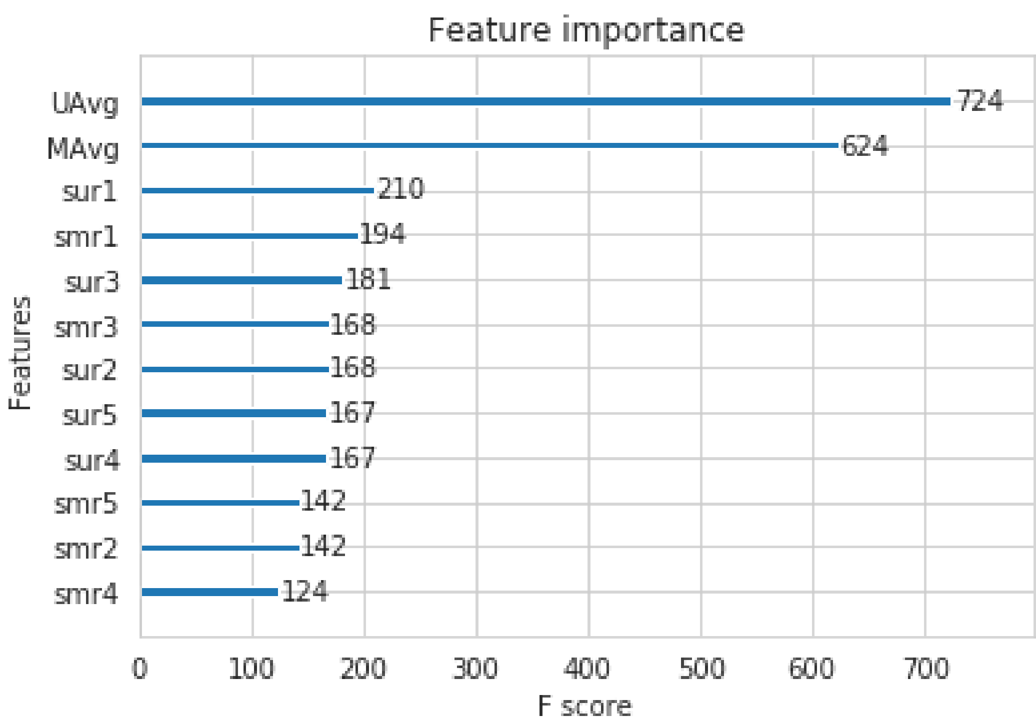
```
[CV] ... max_depth=5, learning_rate=0.1, total=   6.8s
[CV] max_depth=5, learning_rate=0.1 ...
[06:41:34] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate

/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \

[CV] ... max_depth=5, learning_rate=0.1, total=   7.0s
[CV] max_depth=9, learning_rate=0.001 ...
[06:41:41] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate

/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \

[CV] ... max_depth=9, learning_rate=0.001, total=  13.8s
[CV] max_depth=9, learning_rate=0.001 ...
[06:41:55] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate

/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \

[CV] ... max_depth=9, learning_rate=0.001, total=  14.1s
[CV] max_depth=9, learning_rate=0.001 ...
[06:42:09] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate

/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \

[CV] ... max_depth=9, learning_rate=0.001, total=  14.0s
[CV] max_depth=3, learning_rate=1.0 ...
[06:42:23] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate

/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \

[CV] ... max_depth=3, learning_rate=1.0, total=   4.1s
[CV] max_depth=3, learning_rate=1.0 ...
[06:42:27] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate
```

```
/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=1.0, total=   4.1s
[CV] max_depth=3, learning_rate=1.0 ...
[06:42:31] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=1.0, total=   4.2s
[CV] max_depth=3, learning_rate=0.1 ...
[06:42:35] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=0.1, total=   4.1s
[CV] max_depth=3, learning_rate=0.1 ...
[06:42:39] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=0.1, total=   4.1s
[CV] max_depth=3, learning_rate=0.1 ...
[06:42:44] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=0.1, total=   4.2s
[CV] max_depth=3, learning_rate=0.01 ...
[06:42:48] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \
```

```
[CV] ... max_depth=3, learning_rate=0.01, total=   4.0s
[CV] max_depth=3, learning_rate=0.01 ...
[06:42:52] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=0.01, total=   4.2s
[CV] max_depth=3, learning_rate=0.01 ...
[06:42:56] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=3, learning_rate=0.01, total=   4.0s
[CV] max_depth=7, learning_rate=0.01 ...
[06:43:00] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=7, learning_rate=0.01, total=  10.2s
[CV] max_depth=7, learning_rate=0.01 ...
[06:43:10] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=7, learning_rate=0.01, total=  10.4s
[CV] max_depth=7, learning_rate=0.01 ...
[06:43:20] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate


/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \


[CV] ... max_depth=7, learning_rate=0.01, total=  10.1s
[06:43:31] WARNING: /workspace/src/objective/regression_obj.cu:152: reg:linear is now deprecate
```

```
[Parallel(n_jobs=1)]: Done  30 out of  30 | elapsed:  4.0min finished
/usr/local/lib/python3.6/dist-packages/xgboost/core.py:587: FutureWarning: Series.base is depre
  if getattr(data, 'base', None) is not None and \
/usr/local/lib/python3.6/dist-packages/xgboost/core.py:588: FutureWarning: Series.base is depre
  data.base is not None and isinstance(data, np.ndarray) \


Done. Time taken : 0:04:10.438239

Done

Evaluating the model with TRAIN data...
Evaluating Test data

TEST DATA
------------------------------
RMSE :  1.0755881866540673
MAPE :  34.55557960993355
```

In [58]:
```
%matplotlib inline
xgb.plot_importance(first_xgb.best_estimator_)
plt.show()
```



4.4.2 Suprise BaselineModel