In [1]:
```python
%matplotlib inline
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import surprise
from scipy import stats
from ast import literal_eval
from sklearn.feature_extraction.text import TfidfVectorizer, CountVectorizer
from sklearn.metrics.pairwise import linear_kernel, cosine_similarity
from nltk.stem.snowball import SnowballStemmer
from nltk.stem.wordnet import WordNetLemmatizer
from nltk.corpus import wordnet
from surprise import Reader, Dataset, SVD
from surprise.model_selection import cross_validate

import warnings; warnings.simplefilter('ignore')
```

In [2]:
```python
# Simple recomender
md = pd. read_csv('../dataset/movies_metadata.csv')
md.head(10)
```

Out[2]:

	adult	belongs_to_collection	budget	genres	homepage	id	imdb_id	original_
0	False	{'id': 10194, 'name': 'Toy Story Collection', ...	30000000	[{'id': 16, 'name': 'Animation'}, {'id': 35, '...	http://toystory.disney.com/toy-story	862	tt0114709	
1	False	NaN	65000000	[{'id': 12, 'name': 'Adventure'}, {'id': 14, '...	NaN	8844	tt0113497	
2	False	{'id': 119050, 'name': 'Grumpy Old Men Collect...	0	[{'id': 10749, 'name': 'Romance'}, {'id': 35, ...	NaN	15602	tt0113228	
3	False	NaN	16000000	[{'id': 35, 'name': 'Comedy'}, {'id': 18, 'nam...	NaN	31357	tt0114885	
4	False	{'id': 96871, 'name': 'Father of the Bride Col...	0	[{'id': 35, 'name': 'Comedy'}]	NaN	11862	tt0113041	
5	False	NaN	60000000	[{'id': 28, 'name': 'Action'}, {'id': 80, 'nam...	NaN	949	tt0113277	
6	False	NaN	58000000	[{'id': 35, 'name': 'Comedy'}, {'id': 10749, '...	NaN	11860	tt0114319	
7	False	NaN	0	[{'id': 28, 'name': 'Action'}, {'id': 12, 'nam...	NaN	45325	tt0112302	
8	False	NaN	35000000	[{'id': 28, 'name': 'Action'}, {'id': 12, 'nam...	NaN	9091	tt0114576	
9	False	{'id': 645, 'name': 'James Bond Collection', '...	58000000	[{'id': 12, 'name': 'Adventure'}, {'id': 28, '...	http://www.mgm.com/view/movie/757/Goldeneye/	710	tt0113189	

10 rows × 24 columns

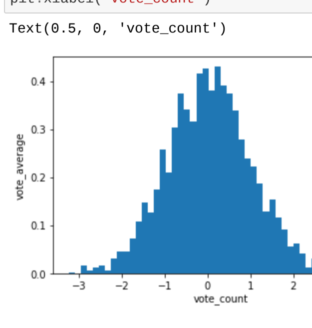
In [3]:
```python
md['genres'] = md['genres'].fillna('[]').apply(literal_eval).apply(lambda x: [i['name'] for
i in x] if isinstance(x, list) else [])
```

In [4]:
```python
vote_counts = md[md['vote_count'].notnull()]['vote_count'].astype('int')
vote_averages = md[md['vote_average'].notnull()]['vote_average'].astype('int')
C = vote_averages.mean()
print(C)
```

```
5.244896612406511
```

In [5]:
```python
np.random.seed(42)
x = np.random.normal(size=2000)
plt.hist(x, density=True, bins=50)
plt.ylabel('vote_average')
plt.xlabel('vote_count')
```

Out[5]: `Text(0.5, 0, 'vote_count')`



In [6]:
```python
m = vote_counts.quantile(0.96)
print(m)
```

```
576.6399999999994
```

In [7]:
```python
md['year'] = pd.to_datetime(md['release_date'], errors='coerce').apply(lambda x: str(x).spli
t('-')[0] if x != np.nan else np.nan)
```

In [8]:
```python
qualified = md[(md['vote_count'] >= m) & (md['vote_count'].notnull()) & (md['vote_average'].
notnull())][['title', 'year', 'vote_count', 'vote_average', 'popularity', 'genres']]
qualified['vote_count'] = qualified['vote_count'].astype('int')
qualified['vote_average'] = qualified['vote_average'].astype('int')
qualified.shape
```

Out[8]: `(1819, 6)`

In [9]:
```python
def weighted_rating(x):
    v = x['vote_count']
    R = x['vote_average']
    return (v/(v+m) * R) + (m/(m+v) * C)
```

In [10]:
```python
qualified['wr'] = qualified.apply(weighted_rating, axis=1)
```

In [11]:
```python
qualified = qualified.sort_values('wr', ascending=False).head(250)
```

In [12]:
```python
qualified.head(15)
```

Out[12]:

	title	year	vote_count	vote_average	popularity	genres	wr
15480	Inception	2010	14075	8	29.1081	[Action, Thriller, Science Fiction, Mystery, A...	7.891568
12481	The Dark Knight	2008	12269	8	123.167	[Drama, Action, Crime, Thriller]	7.876324
22879	Interstellar	2014	11187	8	32.2135	[Adventure, Drama, Science Fiction]	7.864948
2843	Fight Club	1999	9678	8	63.8696	[Drama]	7.845075
4863	The Lord of the Rings: The Fellowship of the Ring	2001	8892	8	32.0707	[Adventure, Fantasy, Action]	7.832214
292	Pulp Fiction	1994	8670	8	140.95	[Thriller, Crime]	7.828186
314	The Shawshank Redemption	1994	8358	8	51.6454	[Drama, Crime]	7.822186
7000	The Lord of the Rings: The Return of the King	2003	8226	8	29.3244	[Adventure, Fantasy, Action]	7.819520
351	Forrest Gump	1994	8147	8	48.3072	[Comedy, Drama, Romance]	7.817885
5814	The Lord of the Rings: The Two Towers	2002	7641	8	29.4235	[Adventure, Fantasy, Action]	7.806672
256	Star Wars	1977	6778	8	42.1497	[Adventure, Action, Science Fiction]	7.783986
1225	Back to the Future	1985	6239	8	25.7785	[Adventure, Comedy, Science Fiction, Family]	7.766903
834	The Godfather	1972	6024	8	41.1093	[Drama, Crime]	7.759311
1154	The Empire Strikes Back	1980	5998	8	19.471	[Adventure, Action, Science Fiction]	7.758359
46	Se7en	1995	5915	8	18.4574	[Crime, Mystery, Thriller]	7.755269

In [13]:
```python
s = md.apply(lambda x: pd.Series(x['genres']),axis=1).stack().reset_index(level=1, drop=True
)
s.name = 'genre'
gen_md = md.drop('genres', axis=1).join(s)
```

In [14]:
```python
def build_chart(genre, percentile=0.85):
    df = gen_md[gen_md['genre'] == genre]
    vote_counts = df[df['vote_count'].notnull()]['vote_count'].astype('int')
    vote_averages = df[df['vote_average'].notnull()]['vote_average'].astype('int')
    C = vote_averages.mean()
    m = vote_counts.quantile(percentile)

    qualified = df[(df['vote_count'] >= m) & (df['vote_count'].notnull()) & (df['vote_averag
e'].notnull())][['title', 'year', 'vote_count', 'vote_average', 'popularity']]
    qualified['vote_count'] = qualified['vote_count'].astype('int')
    qualified['vote_average'] = qualified['vote_average'].astype('int')

    qualified['wr'] = qualified.apply(lambda x: (x['vote_count']/(x['vote_count']+m) * x['vo
te_average']) + (m/(m+x['vote_count']) * C), axis=1)
    qualified = qualified.sort_values('wr', ascending=False).head(250)

    return qualified
```

In [15]:
```python
build_chart('Romance').head(15)
```

Out[15]:

	title	year	vote_count	vote_average	popularity	wr
10309	Dilwale Dulhania Le Jayenge	1995	661	9	34.457	8.565285
351	Forrest Gump	1994	8147	8	48.3072	7.971357
876	Vertigo	1958	1162	8	18.2082	7.811667
40251	Your Name.	2016	1030	8	34.461252	7.789489
883	Some Like It Hot	1959	835	8	11.8451	7.745154
1132	Cinema Paradiso	1988	834	8	14.177	7.744878
19901	Paperman	2012	734	8	7.19863	7.713951
37863	Sing Street	2016	669	8	10.672862	7.689483
882	The Apartment	1960	498	8	11.9943	7.599317
38718	The Handmaiden	2016	453	8	16.727405	7.566166
3189	City Lights	1931	444	8	10.8915	7.558867
24886	The Way He Looks	2014	262	8	5.71127	7.331363
45437	In a Heartbeat	2017	146	8	20.82178	7.003959
1639	Titanic	1997	7770	7	26.8891	6.981546
19731	Silver Linings Playbook	2012	4840	7	14.4881	6.970581

In [16]:
```python
# content based recomender
links_small = pd.read_csv('../dataset/links_small.csv')
links_small = links_small[links_small['tmdbId'].notnull()]['tmdbId'].astype('int')
```

In [17]:
```python
md = md.drop([19730, 29503, 35587])
```

In [18]:
```python
#Check EDA Notebook for how and why I got these indices.
md['id'] = md['id'].astype('int')
```

In [19]:
```python
smd = md[md['id'].isin(links_small)]
print(smd.shape)
```

```
(9099, 25)
```

In [20]:
```python
# Movie Description Based Recommender
smd['tagline'] = smd['tagline'].fillna('')
smd['description'] = smd['overview'] + smd['tagline']
smd['description'] = smd['description'].fillna('')
```

In [21]:
```python
tf = TfidfVectorizer(analyzer='word',ngram_range=(1, 2),min_df=0, stop_words='english')
tfidf_matrix = tf.fit_transform(smd['description'])
```

In [22]:
```python
print(tfidf_matrix.shape)
```

```
(9099, 268124)
```

In [23]:
```python
cosine_sim = linear_kernel(tfidf_matrix, tfidf_matrix)
```

In [24]:
```python
print(cosine_sim[0])
```

```
[1.         0.00680476 0.         ... 0.         0.00344913 0.        ]
```

In [25]:
```python
smd = smd.reset_index()
titles = smd['title']
indices = pd.Series(smd.index, index=smd['title'])
```

In [26]:
```python
def get_recommendations(title):
    idx = indices[title]
    sim_scores = list(enumerate(cosine_sim[idx]))
    sim_scores = sorted(sim_scores, key=lambda x: x[1], reverse=True)
    sim_scores = sim_scores[1:31]
    movie_indices = [i[0] for i in sim_scores]
    return titles.iloc[movie_indices]
```

In [27]:
```python
get_recommendations('Interstellar').head(10)
```

Out[27]:
```
4208       Suburban Commando
1312                 Gattaca
4442     Final Destination 2
3056           Space Cowboys
7669         All Good Things
282                 Stargate
8032              Prometheus
2631     They Might Be Giants
1260                   Spawn
1329       Starship Troopers
Name: title, dtype: object
```

In [28]:
```python
get_recommendations('Inception').head(10)
```

Out[28]:
```
5239                             Cypher
141                               Crumb
6398                        Renaissance
653                           Lone Star
1703                              House
4739                    The Pink Panther
319                                Cobb
2828    What Ever Happened to Baby Jane?
8867                     Pitch Perfect 2
979          Once Upon a Time in America
Name: title, dtype: object
```

In [29]:
```python
# Meta data based recomender
credits = pd.read_csv('../dataset/credits.csv')
keywords = pd.read_csv('../dataset/keywords.csv')
```

In [30]:
```python
keywords['id'] = keywords['id'].astype('int')
credits['id'] = credits['id'].astype('int')
md['id'] = md['id'].astype('int')
```

In [31]:
```python
print(md.shape)
```

```
(45463, 25)
```

In [32]:
```python
md = md.merge(credits, on='id')
md = md.merge(keywords, on='id')
```

In [33]:
```python
smd = md[md['id'].isin(links_small)]
print(smd.shape)
```

```
(9219, 28)
```

In [34]:
```python
# crew and cast
smd['cast'] = smd['cast'].apply(literal_eval)
smd['crew'] = smd['crew'].apply(literal_eval)
smd['keywords'] = smd['keywords'].apply(literal_eval)
smd['cast_size'] = smd['cast'].apply(lambda x: len(x))
smd['crew_size'] = smd['crew'].apply(lambda x: len(x))
```

In [35]:
```python
def get_director(x):
    for i in x:
        if i['job'] == 'Director':
            return i['name']
    return np.nan
```

In [36]:
```python
smd['director'] = smd['crew'].apply(get_director)
```

In [37]:
```python
smd['cast'] = smd['cast'].apply(lambda x: [i['name'] for i in x] if isinstance(x, list) else
[])
smd['cast'] = smd['cast'].apply(lambda x: x[:3] if len(x) >=3 else x)
```

In [38]:
```python
smd['keywords'] = smd['keywords'].apply(lambda x: [i['name'] for i in x] if isinstance(x, li
st) else [])
```

In [39]:
```python
smd['cast'] = smd['cast'].apply(lambda x: [str.lower(i.replace(" ", "")) for i in x])
```

In [40]:
```python
smd['director'] = smd['director'].astype('str').apply(lambda x: str.lower(x.replace(" ", ""
)))
smd['director'] = smd['director'].apply(lambda x: [x,x, x])
```

In [41]:
```python
# keywords
s = smd.apply(lambda x: pd.Series(x['keywords']),axis=1).stack().reset_index(level=1, drop=T
rue)
s.name = 'keyword'
```

In [42]:
```python
s = s.value_counts()
s[:5]
```

Out[42]:
```
independent film        610
woman director          550
murder                  399
duringcreditsstinger    327
based on novel          318
Name: keyword, dtype: int64
```

In [43]:
```python
s = s[s > 1]
```

In [44]:
```python
stemmer = SnowballStemmer('english')
stemmer.stem('dogs')
```

Out[44]: `'dog'`

In [45]:
```python
def filter_keywords(x):
    words = []
    for i in x:
        if i in s:
            words.append(i)
    return words
```

In [46]:
```python
smd['keywords'] = smd['keywords'].apply(filter_keywords)
smd['keywords'] = smd['keywords'].apply(lambda x: [stemmer.stem(i) for i in x])
smd['keywords'] = smd['keywords'].apply(lambda x: [str.lower(i.replace(" ", "")) for i in x
])
```

In [47]:
```python
smd['soup'] = smd['keywords'] + smd['cast'] + smd['director'] + smd['genres']
smd['soup'] = smd['soup'].apply(lambda x: ' '.join(x))
```

In [48]:
```python
count = CountVectorizer(analyzer='word',ngram_range=(1, 2),min_df=0, stop_words='english')
count_matrix = count.fit_transform(smd['soup'])
```

In [49]:
```python
cosine_sim = cosine_similarity(count_matrix, count_matrix)
```

In [50]:
```python
smd = smd.reset_index()
titles = smd['title']
indices = pd.Series(smd.index, index=smd['title'])
```

In [51]:
```python
get_recommendations('Interstellar').head(10)
```

Out[51]:
```
7648               Inception
2085               Following
6623            The Prestige
6981         The Dark Knight
3381                 Memento
4145                Insomnia
8031   The Dark Knight Rises
4153          Silent Running
6218           Batman Begins
8983             The Martian
Name: title, dtype: object
```

In [52]:
```python
get_recommendations('Inception').head(10)
```

Out[52]:
```
6623                             The Prestige
3381                                  Memento
4145                                 Insomnia
2085                                Following
8031                    The Dark Knight Rises
8613                             Interstellar
6981                          The Dark Knight
6218                            Batman Begins
5638    Sky Captain and the World of Tomorrow
8500                                  Don Jon
Name: title, dtype: object
```

In [53]:
```python
def improved_recommendations(title):
    idx = indices[title]
    sim_scores = list(enumerate(cosine_sim[idx]))
    sim_scores = sorted(sim_scores, key=lambda x: x[1], reverse=True)
    sim_scores = sim_scores[1:26]
    movie_indices = [i[0] for i in sim_scores]

    movies = smd.iloc[movie_indices][['title', 'vote_count', 'vote_average', 'year']]
    vote_counts = movies[movies['vote_count'].notnull()]['vote_count'].astype('int')
    vote_averages = movies[movies['vote_average'].notnull()]['vote_average'].astype('int')
    C = vote_averages.mean()
    m = vote_counts.quantile(0.60)
    qualified = movies[(movies['vote_count'] >= m) & (movies['vote_count'].notnull()) & (mov
ies['vote_average'].notnull())]
    qualified['vote_count'] = qualified['vote_count'].astype('int')
    qualified['vote_average'] = qualified['vote_average'].astype('int')
    qualified['wr'] = qualified.apply(weighted_rating, axis=1)
    qualified = qualified.sort_values('wr', ascending=False).head(10)
    return qualified
```

In [54]:
```python
improved_recommendations('Interstellar')
```

Out[54]:

	title	vote_count	vote_average	year	wr
7648	Inception	14075	8	2010	7.891568
6981	The Dark Knight	12269	8	2008	7.876324
6623	The Prestige	4510	8	2006	7.687671
3381	Memento	4168	8	2000	7.665158
8031	The Dark Knight Rises	9263	7	2012	6.897144
6218	Batman Begins	7511	7	2005	6.874863
8983	The Martian	7442	7	2015	6.873786
756	2001: A Space Odyssey	3075	7	1968	6.722847
8384	Oblivion	4862	6	2013	5.919939
8854	Terminator Genisys	3677	5	2015	5.033199

In [55]:
```python
improved_recommendations('Inception')
```

Out[55]:

	title	vote_count	vote_average	year	wr
6981	The Dark Knight	12269	8	2008	7.876324
8613	Interstellar	11187	8	2014	7.864948
6623	The Prestige	4510	8	2006	7.687671
3381	Memento	4168	8	2000	7.665158
8031	The Dark Knight Rises	9263	7	2012	6.897144
6218	Batman Begins	7511	7	2005	6.874863
4173	Minority Report	2663	7	2002	6.687600
8207	Looper	4777	6	2012	5.918668
7286	X-Men Origins: Wolverine	4086	6	2009	5.906615
7903	Green Lantern	2551	5	2011	5.045151

In [56]:
```python
# Collaborative Filtering
reader = Reader()
ratings = pd.read_csv('../dataset/ratings_small.csv')
ratings.head()
```

Out[56]:

	userId	movieId	rating	timestamp
0	1	31	2.5	1260759144
1	1	1029	3.0	1260759179
2	1	1061	3.0	1260759182
3	1	1129	2.0	1260759185
4	1	1172	4.0	1260759205

In [57]:
```python
data = Dataset.load_from_df(ratings[['userId', 'movieId', 'rating']], reader)
# data.split(n_folds=5)
```

In [58]:
```python
algo = SVD()
cross_validate(algo, data, measures=['RMSE', 'MAE'], cv=5, verbose=True)
```

```
Evaluating RMSE, MAE of algorithm SVD on 5 split(s).

                  Fold 1  Fold 2  Fold 3  Fold 4  Fold 5  Mean    Std
RMSE (testset)    0.8920  0.8992  0.8927  0.8967  0.8994  0.8960  0.0031
MAE (testset)     0.6864  0.6898  0.6895  0.6901  0.6941  0.6900  0.0024
Fit time          4.27    5.73    5.68    5.16    4.43    5.05    0.61
Test time         0.14    0.15    0.11    0.12    0.25    0.15    0.05
```

Out[58]:
```
{'test_rmse': array([0.89200119, 0.89919096, 0.89272531, 0.89674294, 0.89936457]),
 'test_mae': array([0.6864422 , 0.689834  , 0.68947567, 0.69008213, 0.69412443]),
 'fit_time': (4.270570755004883,
  5.729519844055176,
  5.683542013168335,
  5.15916633605957,
  4.431554317474365),
 'test_time': (0.14265084266662598,
  0.14664173126220703,
  0.11301875114440918,
  0.11733746528625488,
  0.25356101989746094)}
```

In [59]:
```python
trainset = data.build_full_trainset()
algo.fit(trainset)
```

Out[59]: `<surprise.prediction_algorithms.matrix_factorization.SVD at 0x20d1d430470>`

In [60]:
```python
ratings[ratings['userId'] == 1]
```

Out[60]:

	userId	movieId	rating	timestamp
0	1	31	2.5	1260759144
1	1	1029	3.0	1260759179
2	1	1061	3.0	1260759182
3	1	1129	2.0	1260759185
4	1	1172	4.0	1260759205
5	1	1263	2.0	1260759151
6	1	1287	2.0	1260759187
7	1	1293	2.0	1260759148
8	1	1339	3.5	1260759125
9	1	1343	2.0	1260759131
10	1	1371	2.5	1260759135
11	1	1405	1.0	1260759203
12	1	1953	4.0	1260759191
13	1	2105	4.0	1260759139
14	1	2150	3.0	1260759194
15	1	2193	2.0	1260759198
16	1	2294	2.0	1260759108
17	1	2455	2.5	1260759113
18	1	2968	1.0	1260759200
19	1	3671	3.0	1260759117

In [61]:
```python
algo.predict(1, 302, 3)
```

Out[61]: `Prediction(uid=1, iid=302, r_ui=3, est=2.5240174611886146, details={'was_impossible': False})`

In [62]:
```python
# Hybrid Recommender
def convert_int(x):
    try:
        return int(x)
    except:
        return np.nan
```

In [63]:
```python
id_map = pd.read_csv('../dataset/links_small.csv')[['movieId', 'tmdbId']]
id_map['tmdbId'] = id_map['tmdbId'].apply(convert_int)
id_map.columns = ['movieId', 'id']
id_map = id_map.merge(smd[['title', 'id']], on='id').set_index('title')
#id_map = id_map.set_index('tmdbId')
```

In [64]:
```python
indices_map = id_map.set_index('id')
```

In [67]:
```python
def hybrid(userId, title):
    idx = indices[title]
    tmdbId = id_map.loc[title]['id']
    #print(idx)
    movie_id = id_map.loc[title]['movieId']

    sim_scores = list(enumerate(cosine_sim[int(idx)]))
    sim_scores = sorted(sim_scores, key=lambda x: x[1], reverse=True)
    sim_scores = sim_scores[1:26]
    movie_indices = [i[0] for i in sim_scores]

    movies = smd.iloc[movie_indices][['title', 'vote_count', 'vote_average', 'year', 'id']]
    movies['est'] = movies['id'].apply(lambda x: algo.predict(userId, indices_map.loc[x]['mo
vieId']).est)
    movies = movies.sort_values('est', ascending=False)
    return movies.head(10)
```

In [68]:
```python
hybrid(1, 'Aliens')
```

Out[68]:

	title	vote_count	vote_average	year	id	est
522	Terminator 2: Judgment Day	4274.0	7.7	1991	280	3.087963
987	Alien	4564.0	7.9	1979	348	3.032925
3935	Impostor	136.0	6.1	2001	4965	2.907249
1011	The Terminator	4208.0	7.4	1984	218	2.859904
6640	Déjà Vu	1519.0	6.6	2006	7551	2.856039
922	The Abyss	822.0	7.1	1989	2756	2.812092
7488	Avatar	12114.0	7.2	2009	19995	2.734490
7498	Daybreakers	646.0	6.0	2009	19901	2.714253
7828	I Am Number Four	1606.0	5.9	2011	46529	2.637599
7939	Gantz	73.0	6.5	2011	56832	2.608473

In [69]:
```python
hybrid(500, 'Aliens')
```

Out[69]:

	title	vote_count	vote_average	year	id	est
4347	Piranha Part Two: The Spawning	41.0	3.9	1981	31646	3.344579
6967	Doomsday	374.0	5.8	2008	13460	3.344354
987	Alien	4564.0	7.9	1979	348	3.299576
8468	Riddick	2066.0	6.2	2013	87421	3.248130
7939	Gantz	73.0	6.5	2011	56832	3.223737
6905	I Am Legend	4977.0	6.9	2007	6479	3.081382
7828	I Am Number Four	1606.0	5.9	2011	46529	3.040592
344	True Lies	1138.0	6.8	1994	36955	3.035195
8042	The Darkest Hour	474.0	4.8	2011	71469	3.032956
1360	Alien: Resurrection	1388.0	5.9	1997	8078	2.990499

Conclusion