Recommendation Systems - Module Project

- **DOMAIN:** Smartphone, Electronics

- **CONTEXT:**

India is the second largest market globally for smartphones after China. About 134 million smartphones were sold across India in the year 2017 and is estimated to increase to about 442 million in 2022. India ranked second in the average time spent on mobile web by smartphone users across Asia Pacific. The combination of very high sales volumes and the average smartphone consumer behaviour has made India a very attractive market for foreign vendors. As per Consumer behaviour, 97% of consumers turn to a search engine when they are buying a product vs. 15% who turn to social media. If a seller succeeds to publish smartphones based on user's behaviour/choice at the right place, there are 90% chances that user will enquire for the same. This Case Study is targeted to build a recommendation system based on individual consumer's behaviour or choice.

- **DATA DESCRIPTION:** Phone Reviews

• author : name of the person who gave the rating
• country : country the person who gave the rating belongs to
• date : date of the rating
• domain: website from which the rating was taken from
• extract: rating content
• language: language in which the rating was given
• product: name of the product/mobile phone for which the rating was given
• score: average rating for the phone
• score_max: highest rating given for the phone
• source: source from where the rating was taken

- **PROJECT OBJECTIVE:**

We will build a recommendation system using popularity based and collaborative filtering methods to recommend mobile phones to a user which are most popular and personalised respectively.

In [1]:
```
# imports
import os
import numpy as np
import seaborn as sns
from pprint import pprint
from pathlib import Path
```

```
import matplotlib.pyplot as plt
import pandas as pd, numpy as np
from sklearn.preprocessing import StandardScaler


%matplotlib inline
```

1. Import and explore the data.

In [2]:
```
# import data from "Data Set" Folder
file_paths = [f for f in os.listdir('./Data Set/')  if os.path.splitext(f)[1] == '.csv'
print(file_paths)
# MERGE Data Frames
FULL_DF = pd.DataFrame()
for fp in file_paths:
    # engine{‘c’, ‘python’}, optionalParser engine to use. (to handle encoding in text)
    # The C engine is faster while the python engine is currently more feature-complete
    df = pd.read_csv(f'./Data Set/{fp}', engine='python')
    FULL_DF = pd.concat([df, FULL_DF])
```

```
['phone_user_review_file_1.csv', 'phone_user_review_file_2.csv', 'phone_user_review_file
_3.csv', 'phone_user_review_file_4.csv', 'phone_user_review_file_5.csv', 'phone_user_rev
iew_file_6.csv']
```

In [3]:
```
full_df = FULL_DF.copy(deep=True)
```

In [4]:
```
full_df.shape
```

Out[4]:
```
(1415133, 11)
```

In [5]:
```
full_df.sample(5)
```

Out[5]:

	phone_url	date	lang	country	source	domain	score	score_max	
72400	/cellphones/oneplus-3/	7/18/2016	en	in	Amazon	amazon.in	10.0	10.0	Th
223170	/cellphones/motorola-moto-g3/	9/22/2015	en	in	Amazon	amazon.in	8.0	10.0	Exce
295633	/cellphones/sony-ericsson-w980/	8/7/2008	ru	ua	Hotline.ua	hotline.ua	8.0	10.0	Ñ„Ñ
105157	/cellphones/samsung-galaxy-s6/	8/26/2016	nl	nl	Belsimpel	belsimpel.nl	10.0	10.0	
75589	/cellphones/samsung-galaxy-s-iii-neo-i9300i/	10/20/2014	es	es	Amazon	amazon.es	10.0	10.0	ho

In [6]:
```
full_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1415133 entries, 0 to 374909
Data columns (total 11 columns):
 #   Column     Non-Null Count    Dtype  
---  ------     --------------    -----  
 0   phone_url  1415133 non-null  object 
 1   date       1415133 non-null  object 
 2   lang       1415133 non-null  object 
 3   country    1415133 non-null  object 
 4   source     1415133 non-null  object 
 5   domain     1415133 non-null  object 
 6   score      1351644 non-null  float64
 7   score_max  1351644 non-null  float64
 8   extract    1395772 non-null  object 
 9   author     1351931 non-null  object 
 10  product    1415132 non-null  object 
dtypes: float64(2), object(9)
memory usage: 129.6+ MB
```

In [7]:
```
full_df.isna().sum()  # check for missing values
```

Out[7]:
```
phone_url        0
date             0
lang             0
country          0
source           0
domain           0
score        63489
score_max    63489
extract      19361
author       63202
product          1
dtype: int64
```

In [8]:
```
full_df.score_max.value_counts(dropna=False, normalize=True)
```

Out[8]:
```
10.0    0.955136
NaN     0.044864
Name: score_max, dtype: float64
```

> There are 4% of missing values in the score (target variable) and score_max columns; Hence, we drop these rows from the data frame as we can't use these data points for building our recommendation systems. Also, we drop score_max column as it has only a single value 10 for all non-missing data points. Hence, it adds no information

In [9]:
```
full_df.dropna(subset=['score'], inplace=True) # drop rows if score is missing
```

In [10]:
```
full_df.drop(['score_max'], axis=1, inplace=True) # drop score_max
```

In [11]:
```
full_df['score'] = full_df.score.apply(lambda x: round(x))  # round off scores to neare
full_df['score'].value_counts(normalize=True)
```

Out[11]:
```
10    0.492547
8     0.226058
2     0.095263
6     0.087559
4     0.054255
9     0.030039
```

```
7     0.006489
5     0.003499
1     0.002400
3     0.001859
0     0.000031
Name: score, dtype: float64
```

In [12]:
```
# drop rows with zero rating
full_df = full_df[full_df.score > 0]
```

In [13]:
```
full_df[full_df['author'].isnull()] # cannot be imputed
```

Out[13]:

	phone_url	date	lang	country	source	domain	score	
261	/cellphones/asus-p750/	12/5/2008	en	gb	eXpansys	expansys.com	10	I have it fo
262	/cellphones/asus-p750/	7/14/2008	en	gb	eXpansys	expansys.com	10	Very re
263	/cellphones/asus-p750/	5/5/2008	en	gb	eXpansys	expansys.com	10	Quick , reliable
265	/cellphones/asus-p750/	4/21/2008	en	gb	eXpansys	expansys.com	10	I've had this p
266	/cellphones/asus-p750/	2/5/2008	en	gb	eXpansys	expansys.com	2	When it worke
...	...	...	...	...	...	...	...	
374904	/cellphones/huawei-y3/	12/14/2015	ru	ru	Yandex	market.yandex.ru	6	ÐŸÑ€Ð¸Ð½Ñ†Ð±Ñ‹Ð
374905	/cellphones/huawei-y3/	11/30/2015	ru	ru	Yandex	market.yandex.ru	8	Ð² Ñ□Ð°Ð Ð°Ñƒ Ð¿Ð¸
374906	/cellphones/huawei-y3/	11/9/2015	ru	ru	Yandex	market.yandex.ru	8	Ð½Ðµ
374907	/cellphones/huawei-y3/	9/27/2015	ru	ru	Yandex	market.yandex.ru	10	Ð' Ñ†ÐµÐ»Ð¾Ñ
374908	/cellphones/huawei-y3/	9/25/2015	ru	ru	Yandex	market.yandex.ru	8	Ð¡Ð¼Ð°Ñ€Ñ‚Ñ Ð½ÐµÑ‚Ñ

60606 rows × 10 columns

In [14]:
```
(full_df.author.isna().sum() / full_df.shape[0])*100 # 4.4% missing values in author, d
```

Out[14]: 4.484012305397595

In [15]:
```
full_df[full_df['extract'].isnull()] # cannot be imputed, can be dropped when we need c
```

Out[15]:

	phone_url	date	lang	country	source	domain	score	extract
267	/cellphones/asus-p750/	2/10/2013	ru	ru	Irecommend	irecommend.ru	6	NaN
276	/cellphones/asus-p750/	6/30/2011	ru	ru	Yandex	market.yandex.ru	8	NaN
285	/cellphones/asus-p750/	5/14/2010	ru	ru	Irecommend	irecommend.ru	10	NaN
419	/cellphones/nokia-1209/	6/18/2009	ru	ua	Mob.org	mob.ua	8	NaN
588	/cellphones/samsung-sgh-f250/	11/17/2009	ru	ua	Mob.org	mob.ua	8	NaN
...	...	...	...	...	...	...	...	...
371630	/cellphones/lg-g4-stylus-h635/	8/14/2016	ru	ru	Yandex	market.yandex.ru	6	NaN
371948	/cellphones/microsoft-lumia-535/	1/11/2016	en	us	Newegg	newegg.com	10	NaN
372952	/cellphones/microsoft-lumia-535/	1/19/2016	ru	ru	Irecommend	irecommend.ru	8	NaN
373262	/cellphones/microsoft-lumia-535/	8/16/2015	ru	ru	Yandex	market.yandex.ru	8	NaN
374903	/cellphones/huawei-y3/	1/11/2016	ru	ru	Yandex	market.yandex.ru	6	NaN

18945 rows × 10 columns

In [16]:
```
(full_df.extract.isna().sum() / full_df.shape[0])*100 # 1.4% missing values in author,
```

Out[16]: 1.401670018245016

In [17]:
```
full_df.dropna(subset=['extract', 'author'], inplace=True) # drop rows if score is miss
```

In [18]:
```
full_df[full_df['product'].isnull()] # product name missing
```

Out[18]:

phone_url	date	lang	country	source	domain	score	extract	author	product

In [19]:
```
full_df[full_df['phone_url'] == '/cellphones/samsung-galaxy-s-iii/']['product'].value_c
```

Out[19]:
```
Samsung Galaxy S III 16GB (Virgin Mobile)
730
Samsung Galaxy S III
687
Samsung Galaxy Express I8730
603
Samsung Galaxy S III 16GB (Straight Talk)
556
Samsung Galaxy S III i9300 Smartphone 16 GB (12,2 cm (4,8 Zoll) HD Super-AMOLED-Touchscr
een, 8 Megapixel Kamera, Micro-SIM, Android 4.0) schwarz    381

...
Burberry Brit Rhythm Men - Eau de Toilette
1
Jean Paul Gaultier Le Beau Male - Eau de Toilette
1
Laura Biagiotti Laura - Eau de Toilette
1
Valentino Valentina Acqua Floreale - Eau de Toilette
1
Smartphone Samsung I9300 Galaxy S III Preto com Tela 4.8", CÃ¢m. 8MP + 1.9MP Frontal, An
droid 4.0, 3G, Processador Quad-Core e Wi-Fi - Oi             1
Name: product, Length: 337, dtype: int64
```

In [20]:
```
full_df['product'].value_counts(dropna=False) # 56036 unique phone variants
```

Out[20]:
```
Lenovo Vibe K4 Note (White,16GB)
5226
Lenovo Vibe K4 Note (Black, 16GB)
4390
OnePlus 3 (Graphite, 64 GB)
4103
OnePlus 3 (Soft Gold, 64 GB)
3562
Huawei P8lite zwart / 16 GB
2707

...
Samsung Galaxy S7 SM-G930F 32GB 4G Rosa - Smartphone (SIM Ãºnica, Android, NanoSIM, GSM,
TD-SCDMA, UMTS, WCDMA, LTE)       1
Moto G5 Plus XT1683 Platinum Dual Chip Android Nougat 4G 32GB com TV Digital
1
TIM TELEFONO SONY ERICSSON XPERIA U (TIM) BK/PINK
1
Ð¡Ð¾Ñ€Ñ‚,Ñ„Ð¾Ð½ Apple iPhone 7 Plus, MN4C2RU/A (5.5", 3GB RAM, 128Gb, 2900 mAh)
1
Asus ZenFone 2 ZE551ML 4G LTE Dual SIM SIM-Free Smartphone (4GB RAM/64GB ROM) (Gold), [I
mportado de UK]                   1
Name: product, Length: 54872, dtype: int64
```

In [21]:
```
full_df.phone_url.value_counts(dropna=False, normalize=True) # 5541 unique phone models
```

Out[21]:
```
/cellphones/samsung-galaxy-s6/         1.243774e-02
/cellphones/samsung-galaxy-s7-edge/    1.220182e-02
/cellphones/apple-iphone-5s/           1.218223e-02
/cellphones/samsung-galaxy-s5/         1.197766e-02
/cellphones/motorola-moto-g/           1.131067e-02
                                           ...
/cellphones/motorola-m3688/            7.837758e-07
/cellphones/lava-a16-mtv/              7.837758e-07
/cellphones/lenovo-z2-plus/            7.837758e-07
/cellphones/i-mate-ultimate-8150/      7.837758e-07
/cellphones/samsung-sch-n150/          7.837758e-07
Name: phone_url, Length: 5508, dtype: float64
```

> There is one value missing in 'prouct'; However, the variations in each phone model by it's description doesn't make it a new phone and we might not have enough data for each variation of the phone to recommend individual variants of each phone. So, we drop the phone column and preserve only a new column named 'phone_model' which has the information about the main phone model name.

In [22]:
```
full_df.drop(['product'], axis=1, inplace=True) # drop product
```

> Engineered Features: year, phone_model, company

In [23]:
```
full_df['phone_model'] = full_df['phone_url'].apply(lambda x : x.split('/')[-2])
full_df.phone_model.value_counts(dropna=False, ascending=False) # 5541 unique phone mod
```

Out[23]:
```
samsung-galaxy-s6             15869
samsung-galaxy-s7-edge        15568
apple-iphone-5s               15543
samsung-galaxy-s5             15282
motorola-moto-g               14431
                              ...
alcatel-ot-s520                   1
gresso-grand-monaco               1
archos-3-5-internet-tablet        1
lg-ke850                          1
t-mobile-vivacity                 1
Name: phone_model, Length: 5508, dtype: int64
```

In [24]:
```
full_df.drop(['phone_url'], axis=1, inplace=True) # drop phone_url
```

In [25]:
```
full_df['year'] = full_df['date'].apply(lambda x: x.split('/')[-1])
full_df.year.value_counts(ascending=False, dropna=False)
```

Out[25]:
```
2016    234350
2014    228099
2015    219332
2013    162776
2012     96086
2011     75301
2010     64939
2017     47290
2009     46472
2008     32852
2007     22929
2006     12161
2005      8371
2000      8031
2004      5934
2001      4624
2003      3342
2002      2712
1999       273
1970         1
Name: year, dtype: int64
```

In [26]:
```
# changing data column to appropriate data_types
full_df['year'] = pd.to_datetime(full_df['year'], format='%Y')
full_df['date'] = pd.to_datetime(full_df['date'])
```

In [27]:
```
full_df[full_df.year < pd.to_datetime(1999, format='%Y')].phone_model.value_counts() #
```

```
sony-ericsson-xperia-play    1
```

Out[27]:
```
Name: phone_model, dtype: int64
```

In [28]:
```
full_df[full_df.year < pd.to_datetime(2006, format='%Y')].phone_model.value_counts() #
```

Out[28]:
```
nokia-3210                              810
nokia-7110                              575
nokia-6210                              552
siemens-c25                             539
siemens-s25                             509
                                       ...
samsung-sch-i500-showcase-mesmerize       1
sagem-my-s-7                              1
motorola-rokr                             1
lg-b2050                                  1
alcatel-hc-1000                           1
Name: phone_model, Length: 1108, dtype: int64
```

> Given the rapid acceleration of technology, products from older than 2006; i.e, before the smartphone era might not be relevant to the modern era and might not even be available for purchase anymore. So, we drop these phones with reviews older than 2006

In [29]:
```
full_df = full_df[full_df.year >= pd.to_datetime(2006, format='%Y')]
full_df.shape
```

Out[29]:
```
(1242587, 10)
```

In [30]:
```
full_df.year.value_counts()
```

Out[30]:
```
2016-01-01    234350
2014-01-01    228099
2015-01-01    219332
2013-01-01    162776
2012-01-01     96086
2011-01-01     75301
2010-01-01     64939
2017-01-01     47290
2009-01-01     46472
2008-01-01     32852
2007-01-01     22929
2006-01-01     12161
Name: year, dtype: int64
```

In [31]:
```
full_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1242587 entries, 0 to 374909
Data columns (total 10 columns):
 #   Column       Non-Null Count    Dtype
---  ------       --------------    -----
 0   date         1242587 non-null  datetime64[ns]
 1   lang         1242587 non-null  object
 2   country      1242587 non-null  object
 3   source       1242587 non-null  object
 4   domain       1242587 non-null  object
 5   score        1242587 non-null  int64
 6   extract      1242587 non-null  object
 7   author       1242587 non-null  object
 8   phone_model  1242587 non-null  object
 9   year         1242587 non-null  datetime64[ns]
dtypes: datetime64[ns](2), int64(1), object(7)
memory usage: 104.3+ MB
```

In [32]:
```
full_df.isna().sum()  # check for missing values
```

Out[32]:
```
date           0
lang           0
country        0
source         0
domain         0
score          0
extract        0
author         0
phone_model    0
year           0
dtype: int64
```

In [33]:
```
# get the phone company
full_df['company'] = full_df.phone_model.apply(lambda x: x.split('-')[0].strip().lower(
pd.DataFrame(full_df.company.value_counts()).T
```

Out[33]:

	samsung	nokia	lg	sony	apple	motorola	huawei	htc	lenovo	blackberry	...
company	327415	148498	103754	101122	79653	78717	63106	61203	39912	28619	...

1 rows × 161 columns

In [34]:
```
# check for duplicates
duplicates = full_df[full_df.duplicated()]
duplicates
```

Out[34]:

	date	lang	country	source	domain	score	extract	
1198	2012-04-05	ru	ru	Yandex	market.yandex.ru	6	Ð¢ÐµÐ»ÐµÑ„Ð¾Ð½ Ð²Ñ‹Ð·Ð²Ð°Ð» Ð¾Ñ‡ÐµÐ½ÑŒ Ð¿Ð¾Ð»Ñ...	
1377	2010-12-02	ru	ru	Yandex	market.yandex.ru	10	Ð¿Ð¾ÐºÐ°Ñ‚ÐµÐ»ÐµÐ¹ Ð´Ð¾Ð²Ð¾Ð»ÑŒÐ½Ð° Ð...	pe
1802	2008-04-14	de	de	Ciao	ciao.de	10	Gliederung Einleitung/Allgemeines zum Bericht ...	
2535	2014-10-21	ru	ru	Yandex	market.yandex.ru	10	Ð¢ÐµÐ»ÐµÑ„Ð¾Ð½ Ð¿Ñ€Ð¾Ð»Ð¾Ñ‚ Ð¼Ð½Ð¾Ð³Ð¾ Ð²ÐµÑ...	ÐœÐ°Ñ‹ Ðo
2555	2014-03-29	ru	ru	Yandex	market.yandex.ru	10	ÐŸÐ¾Ð»ÑŒÐ·Ð¾Ð²Ð°Ð»Ñ�Ñ‘ Ð´Ð°Ð½Ð½Ñ‹Ð¼ Ñ‚ÐµÐ»ÐµÑ„...	
...	...	...	...	...	...	...	...	
374522	2015-11-21	es	es	Amazon	amazon.es	10	Adquirido en Tri-Color Movil de Gama media, cu...	
374557	2015-10-24	es	es	Amazon	amazon.es	10	Producto Cedido por EverDeals. El Elephone P60...	F
374853	2015-07-18	es	es	Amazon	amazon.es	10	Adquirido en Tri-Color Movil de Gama media, cu...	

	date	lang	country	source	domain	score	extract
374855	2015-07-16	es	es	Amazon	amazon.es	10	Terminal gama media bastante redondo en cuanto...
374856	2015-07-16	es	es	Amazon	amazon.es	10	Terminal gama media bastante redondo en cuanto...

18545 rows × 11 columns

In [35]:
```
full_df = full_df[~full_df.duplicated()]
full_df.shape
```

Out[35]: (1224042, 11)

In [36]:
```
# check for duplicates
duplicates = full_df[full_df.duplicated()]
duplicates
```

Out[36]:

date	lang	country	source	domain	score	extract	author	phone_model	year	company

> Keep only 1000000 data samples. Use random state=612

In [37]:
```
sampled_df = full_df.sample(n=1000000, random_state=612)
sampled_df.shape
```

Out[37]: (1000000, 11)

In [38]:
```
from tqdm.notebook import tqdm
tqdm.pandas()
sampled_df.reset_index(drop=True, inplace=True)
```

```
C:\Users\surya\anaconda3\lib\site-packages\tqdm\std.py:697: FutureWarning: The Panel cla
ss is removed from pandas. Accessing it from the top-level namespace will also be remove
d in the next version
  from pandas import Panel
```

In [39]:
```
# preprocess xtract, author names | normalize unicode, fix text using ftfy
```

In [40]:
```
# !conda install -c conda-forge ftfy
```

In [41]:
```
from ftfy import fix_text
```

In [42]:
```
sampled_df['user'] = sampled_df.author.progress_apply(fix_text)
```

In [43]:
```
sampled_df['review'] = sampled_df.extract.progress_apply(fix_text)
```

In [44]:
```
# pick only relevant features
selected_df = sampled_df[['lang', 'score', 'review', 'user', 'phone_model', 'year', 'co
selected_df.sample(7)
```

Out[44]:

	lang	score	review	user	phone_model	year	company
623794	ru	6	Кра�ивый, удобный, но в первый же день обнаруж...	�на�та�и�	samsung-galaxy-alpha	2016-01-01	samsung
502680	nl	10	Wat een prachtige verschijning de Galaxy S6. B...	Joan T.	samsung-galaxy-s6	2015-01-01	samsung
965487	en	9	As a former G1, Mytouch slide 3G, Vibrant and ...	Eveningstarr	samsung-galaxy-s-blaze	2012-01-01	samsung
260941	en	10	Dope Phone for the price. Got here fast and lo...	Noah	apple-iphone-5c	2013-01-01	apple
723541	de	4	Ich werde hier kurz und knapp Positiv und Nega...	Jules	motorola-droid-2	2013-01-01	motorola
510874	it	10	Ho acquistato questo cellulare dopo anni di de...	ImpronteDigitali	nokia-asha-200	2012-01-01	nokia
901382	en	6	I checked with Samsung support and was told th...	Wayne J.	samsung-galaxy-y-duos	2013-01-01	samsung

2. Analyze

> • Identify the most rated features.
> • Identify the users with most number of reviews.
> • Select the data with products having more than 50 ratings and users who have given more than 50 ratings. Report the shape of the final dataset.

In [45]:
```
viz_df = selected_df.copy()
```

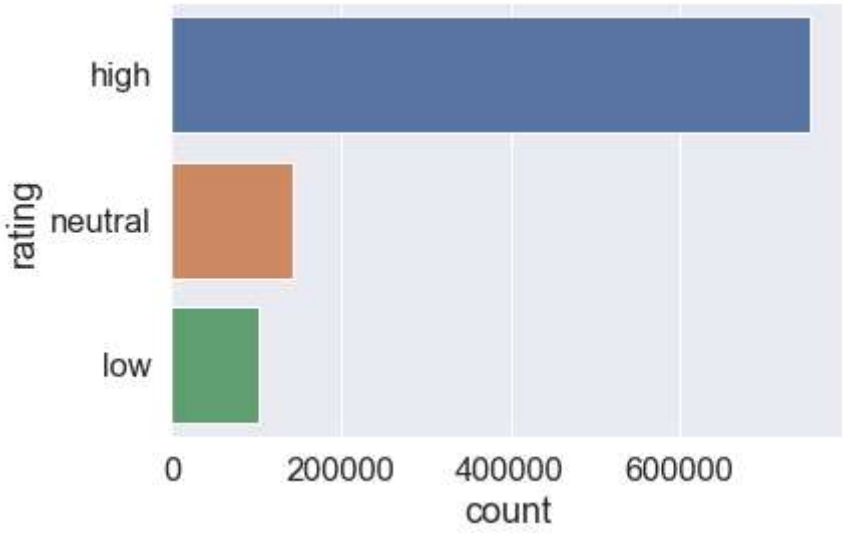
In [46]:
```
# categories of rating for analysis
# 7-10: high
# 4-6:  neutral
# 0-3:  low

def bin_scores(row):
    if row.score>6:
        row['rating'] = 'high'
    elif row.score>3:
        row['rating'] = 'neutral'
    else:
        row['rating'] = 'low'
    return row

viz_df = viz_df.progress_apply(bin_scores, axis=1)
```

In [47]:
```
viz_df.rating.value_counts(dropna=False, normalize=True)
```

Out[47]:
```
high       0.754309
neutral    0.143136
low        0.102555
Name: rating, dtype: float64
```

In [48]:
```
sns.set(font_scale=1.5)
```

```
sns.countplot(data=viz_df, y='rating', order = viz_df['rating'].value_counts().index)
plt.show()
```



> Most phones have high ratings, followed by neutral ratings followed by very less low rated phones.

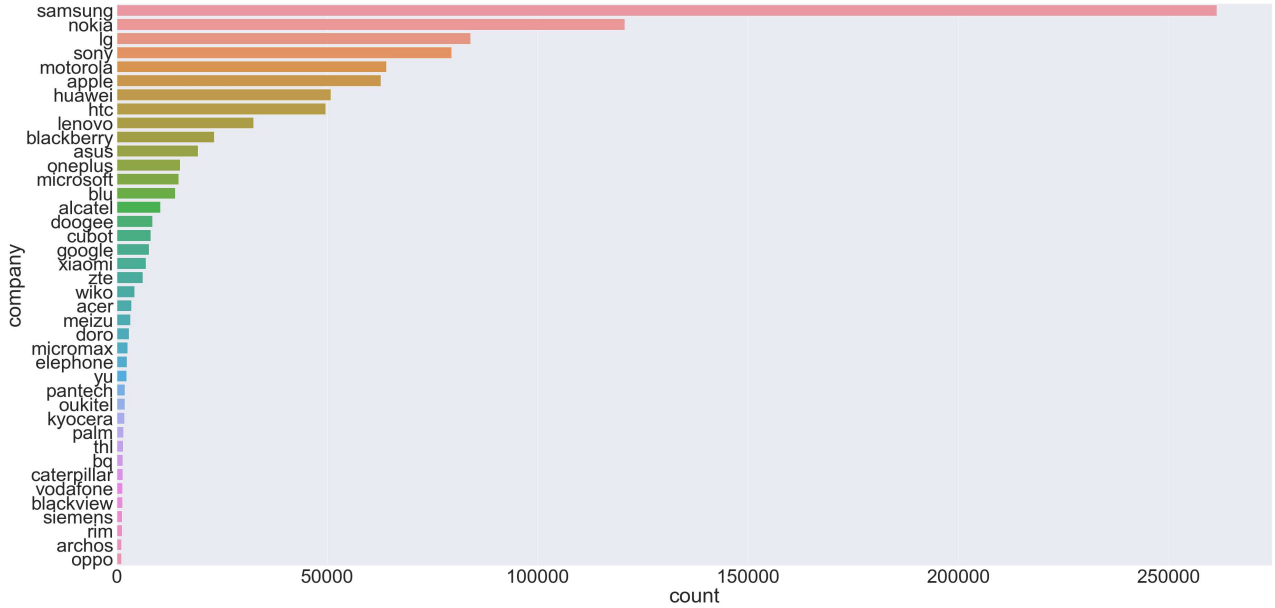
In [49]:
```
temp_df = pd.DataFrame(viz_df.company.value_counts().head(40))
temp_df.T
```

Out[49]:

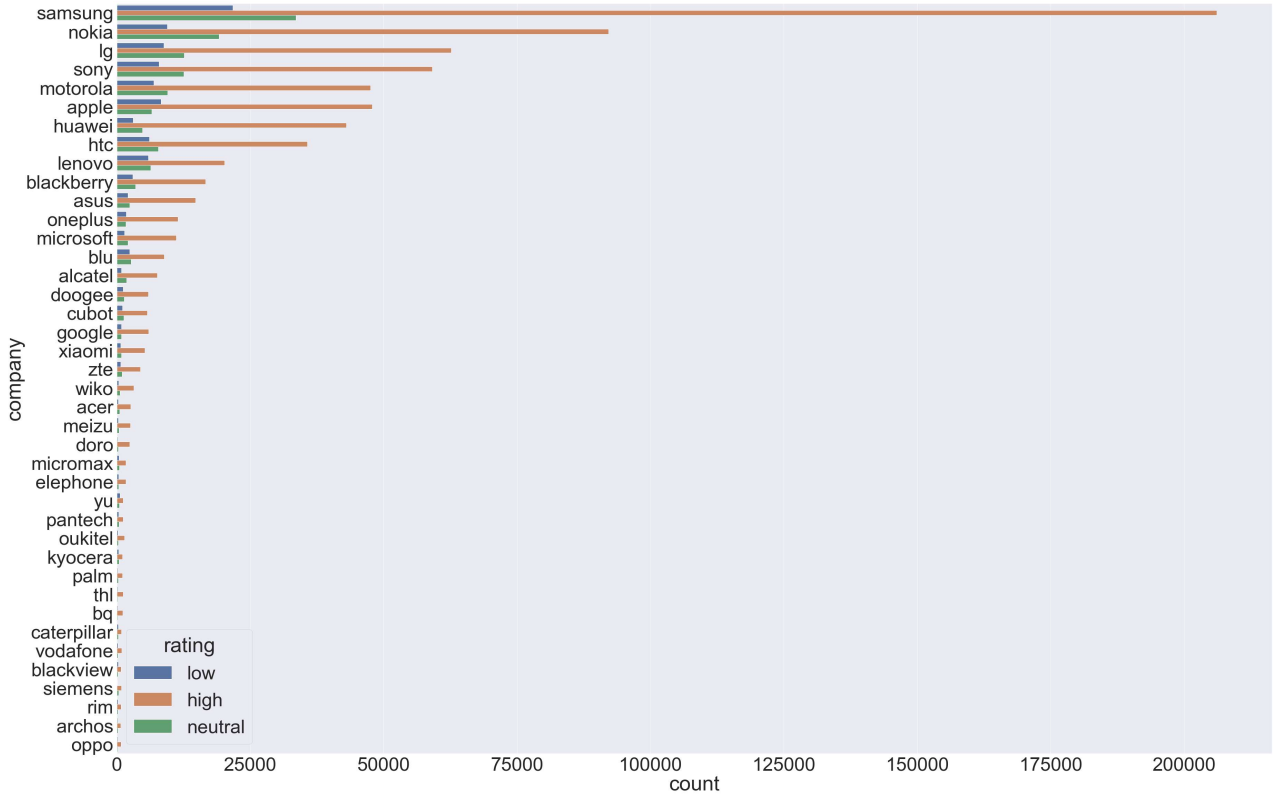
	samsung	nokia	lg	sony	motorola	apple	huawei	htc	lenovo	blackberry	...	p
company	261432	120762	84077	79602	64050	62733	50908	49679	32496	23164	...	1

1 rows × 40 columns

In [50]:
```
sns.set(font_scale=5)
plt.figure(figsize=(60, 30))
top_40_comapnies = list(temp_df.index.unique())
temp_df_ = viz_df[viz_df.company.isin(top_40_comapnies)]
sns.countplot(data=temp_df_, y='company', order = temp_df_['company'].value_counts().in
plt.show()
```



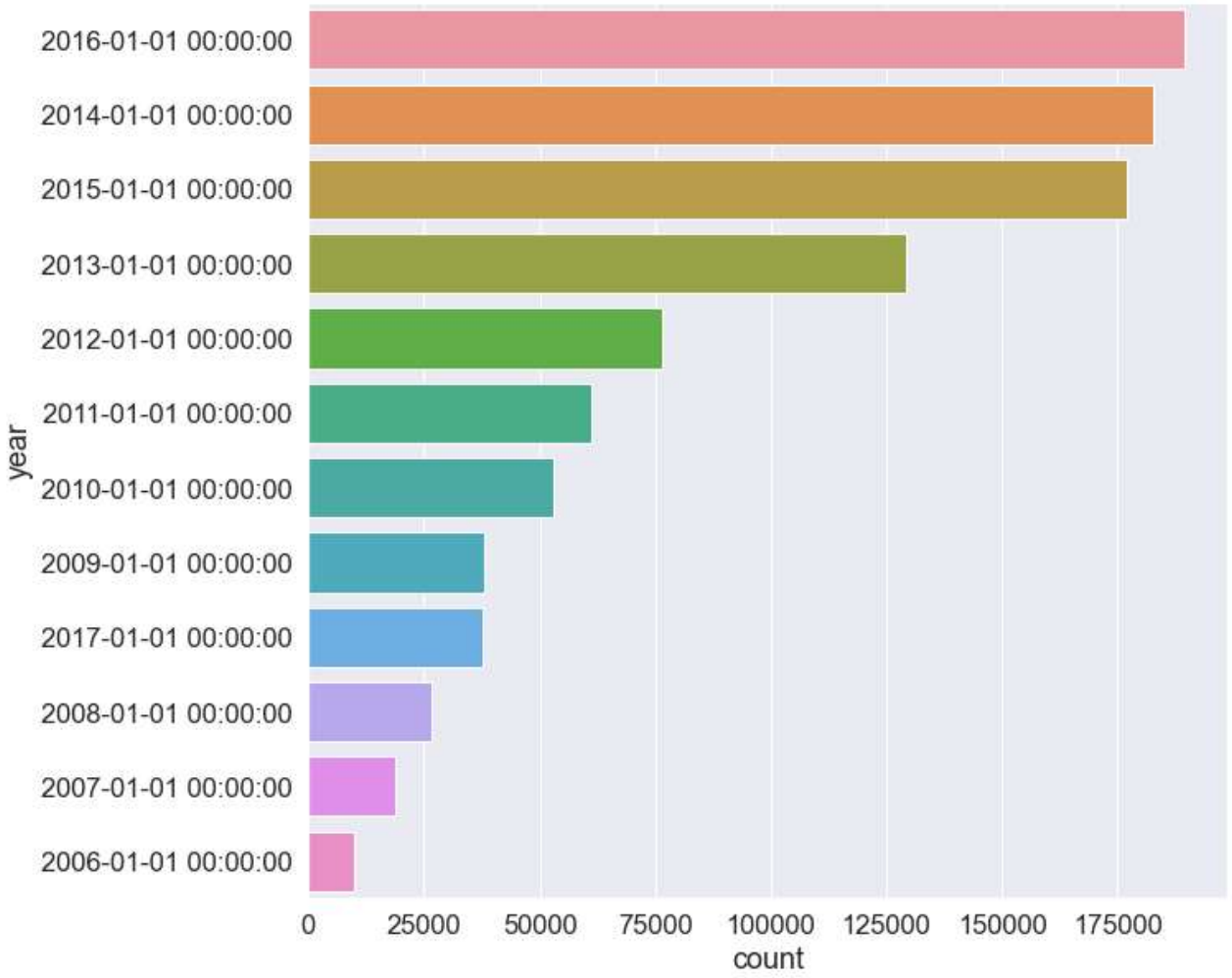
In [51]:
```
sns.set(font_scale=5)
plt.figure(figsize=(60, 40))
top_40_comapnies = list(temp_df.index.unique())
temp_df_ = viz_df[viz_df.company.isin(top_40_comapnies)]
sns.countplot(data=temp_df_, y='company', order = temp_df_['company'].value_counts().in
plt.show()
```



> A few companies like samsung, nokia, lg, sony... seem to have the most number of reviews in our dataset indicative of their market share in the phones market in the given timeperiod fo 2007-2017. Also, we can see that most ratings for all companies seem to be high, and relatively less neutral ratings

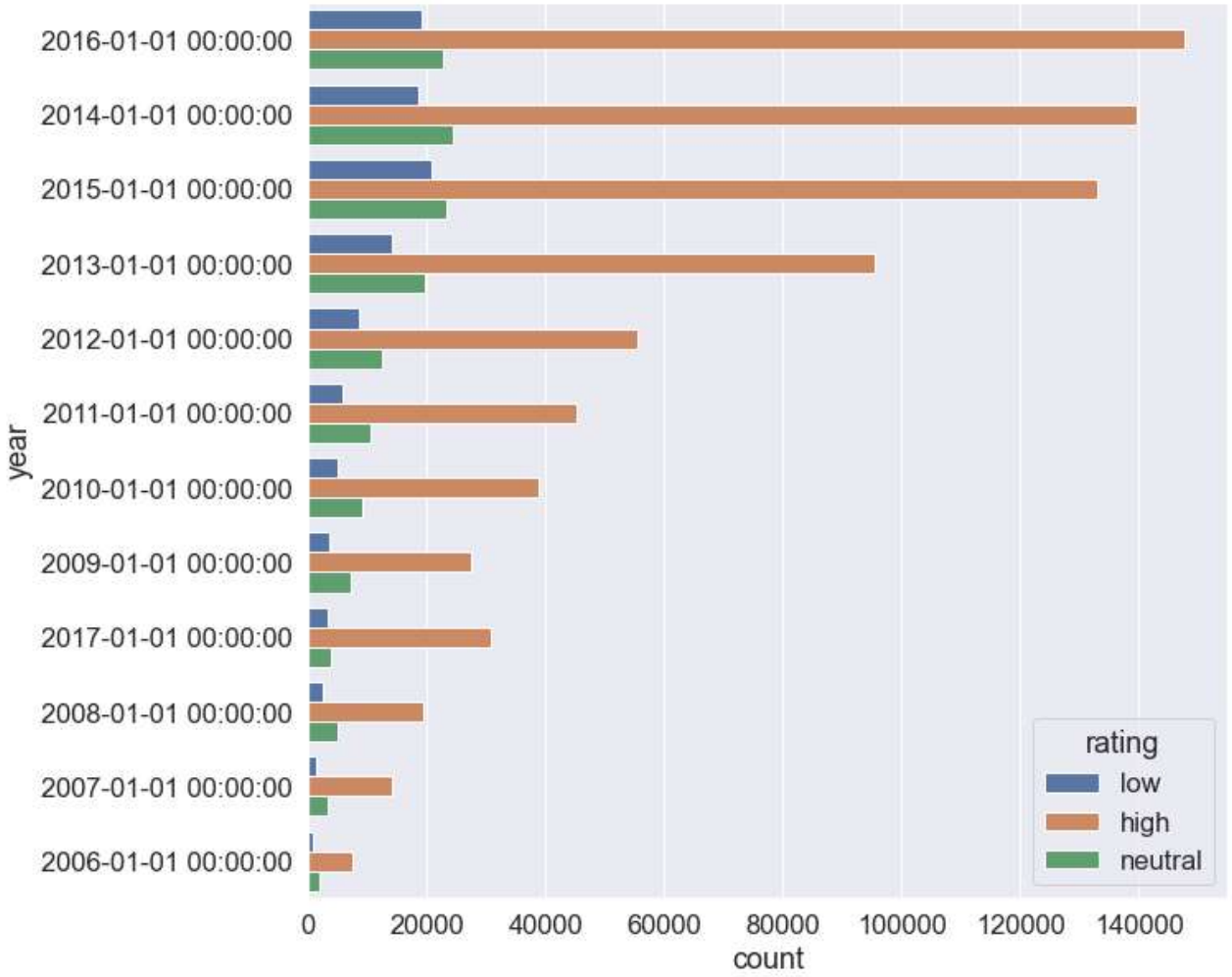
In [52]:
```
sns.set(font_scale=1.5)
```

```
plt.figure(figsize=(10, 10))
sns.countplot(data=viz_df, y='year', order = viz_df['year'].value_counts().index)
plt.show()
```



In [53]:

```
sns.set(font_scale=1.5)
plt.figure(figsize=(10, 10))
sns.countplot(data=viz_df, y='year', order = viz_df['year'].value_counts().index, hue='
plt.show()
```



> Most reviews are from the years 2014, 2015 and 2016 in our dataset. This might cause unnecessary bias for that time period and the predictions might not extend well into the future if the dataset is static

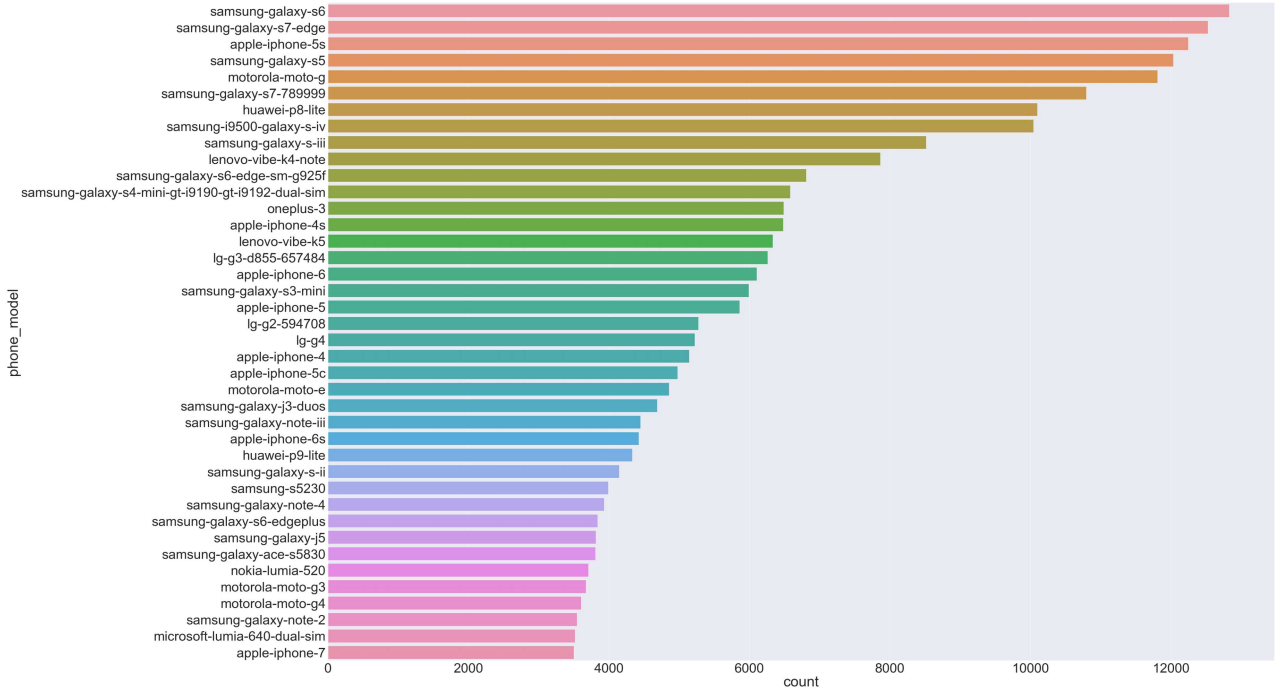
In [54]:
```
temp_df = pd.DataFrame(viz_df.phone_model.value_counts().head(40))
temp_df.T
```

Out[54]:

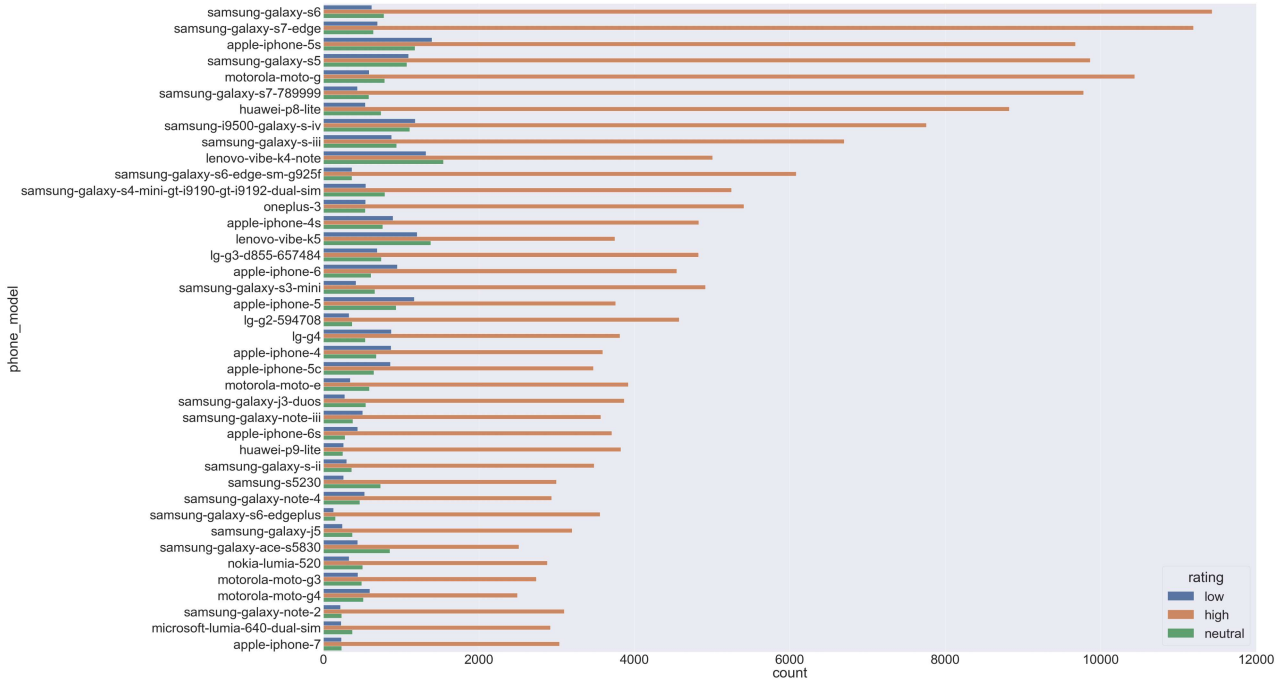
	samsung-galaxy-s6	samsung-galaxy-s7-edge	apple-iphone-5s	samsung-galaxy-s5	motorola-moto-g	samsung-galaxy-s7-789999	huawei-p8-lite	samsung-i9500-galaxy-s-iv	sam gal
phone_model	12831	12528	12248	12033	11810	10797	10099	10043	

1 rows × 40 columns

In [55]:
```
sns.set(font_scale=5)
plt.figure(figsize=(70, 50))
top_40_phones = list(temp_df.index.unique())
temp_df_ = viz_df[viz_df.phone_model.isin(top_40_phones)]
sns.countplot(data=temp_df_, y='phone_model', order = temp_df_['phone_model'].value_cou
plt.show()
```



In [56]:
```
sns.set(font_scale=5)
plt.figure(figsize=(70, 50))
top_40_phones = list(temp_df.index.unique())
temp_df_ = viz_df[viz_df.phone_model.isin(top_40_phones)]
sns.countplot(data=temp_df_, y='phone_model', order = temp_df_['phone_model'].value_cou
plt.show()
```



> A few phones like galaxy s6, s7 and moto g ..etcs., have relatively the most number of reviews and also the most number of high ratings than low, neutral ratings. iphone 5s and other non-flagship phones at the time have good nunmber of high ratings but relatively more number of low, neutral ratings as well

In [57]:
```
temp_df = pd.DataFrame(viz_df.user.value_counts().head(40))
temp_df.T
```

Out[57]:

	Amazon Customer	Cliente Amazon	e-bit	Client d'Amazon	Amazon Kunde	einer Kundin	Anonymous	einem Kunden	unknown	Anonym
user	62546	15696	6843	6289	3811	2115	2093	1539	1402	

1 rows × 40 columns

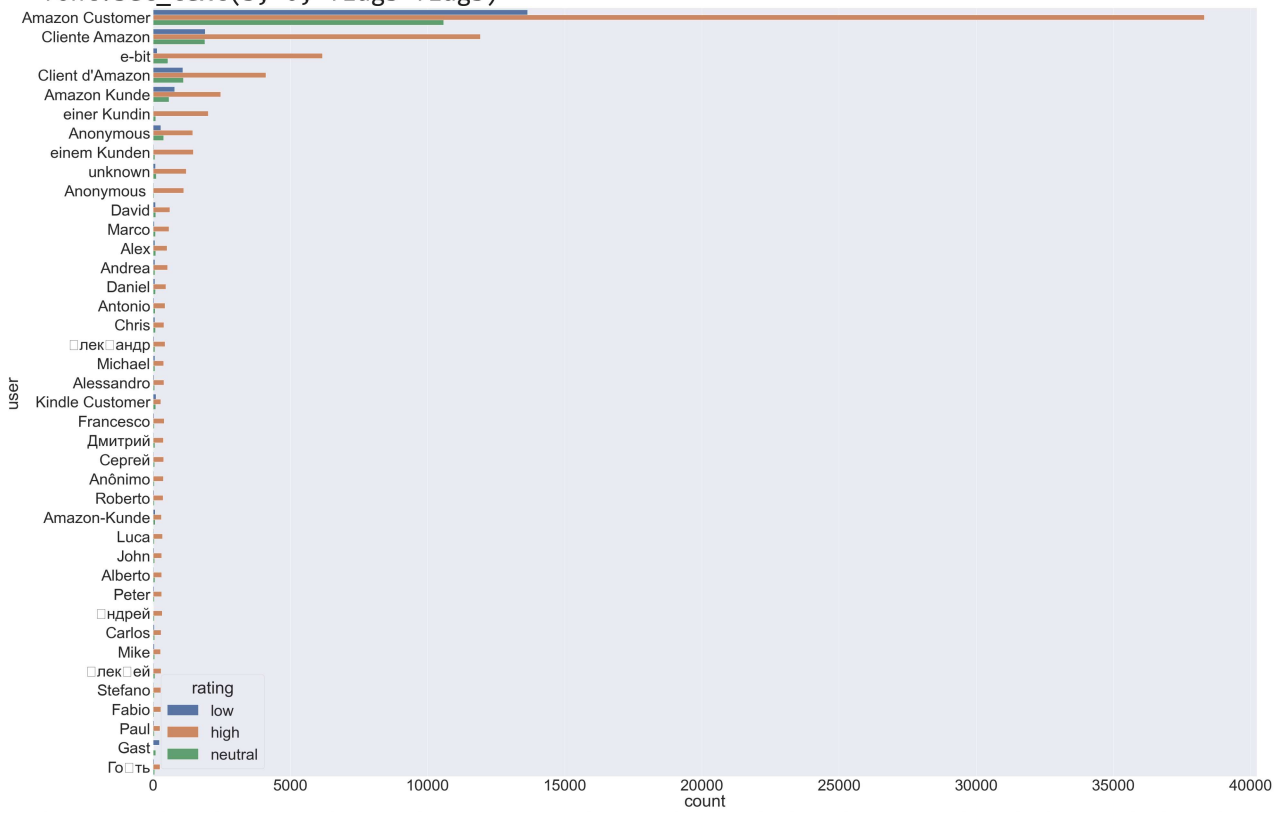
In [58]:
```
sns.set(font_scale=5)
plt.figure(figsize=(70, 50))
top_40_users = list(temp_df.index.unique())
temp_df_ = viz_df[viz_df.user.isin(top_40_users)]
sns.countplot(data=temp_df_, y='user', order = temp_df_['user'].value_counts().index)
plt.show()
```

```
C:\Users\surya\anaconda3\lib\site-packages\matplotlib\backends\backend_agg.py:238: Runti
meWarning: Glyph 65533 missing from current font.
  font.set_text(s, 0.0, flags=flags)
C:\Users\surya\anaconda3\lib\site-packages\matplotlib\backends\backend_agg.py:201: Runti
meWarning: Glyph 65533 missing from current font.
  font.set_text(s, 0, flags=flags)
```

In [60]:
```
sns.set(font_scale=5)
plt.figure(figsize=(70, 50))
top_40_users = list(temp_df.index.unique())
temp_df_ = viz_df[viz_df.user.isin(top_40_users)]
sns.countplot(data=temp_df_, y='user', order = temp_df_['user'].value_counts().index, h
plt.show()
```

```
C:\Users\surya\anaconda3\lib\site-packages\matplotlib\backends\backend_agg.py:238: Runti
meWarning: Glyph 65533 missing from current font.
  font.set_text(s, 0.0, flags=flags)
C:\Users\surya\anaconda3\lib\site-packages\matplotlib\backends\backend_agg.py:201: Runti
```

```
meWarning: Glyph 65533 missing from current font.
  font.set_text(s, 0, flags=flags)
```



> The top 40 users with the most amount of reviews. Some users seem to be generic accounts (Amazon Customer, Client Amazon, Anonymous, Anonimo, unknown...) with many reviews. This might affect personlization of the user-based collaborative filtering.

In [61]:
```
# Select the data with products having more than 50 ratings and users who have given mo
temp_df = pd.DataFrame(selected_df.user.value_counts())
temp_df = temp_df[temp_df.user > 50]
atleast_50_users = list(temp_df.index)
pprint(atleast_50_users[:50], compact=True)
```

```
['Amazon Customer', 'Cliente Amazon', 'e-bit', "Client d'Amazon",
 'Amazon Kunde', 'einer Kundin', 'Anonymous', 'einem Kunden', 'unknown',
 'Anonymous ', 'David', 'Marco', 'Alex', 'Andrea', 'Daniel', 'Antonio', 'Chris',
 '□лек□андр', 'Michael', 'Kindle Customer', 'Alessandro', 'Francesco', 'Сергей',
 'Дмитрий', 'Anônimo', 'Roberto', 'Amazon-Kunde', 'Luca', 'John', 'Alberto',
 'Peter', '□ндрей', 'Carlos', 'Mike', '□лек□ей', 'Stefano', 'Fabio', 'Gast',
 'Paul', 'Го□ть', 'Thomas', 'Giuseppe', 'Jose', 'Laura', 'anonieme bezoeker',
 'Christian', 'Davide', 'Javier', 'Paolo', 'Martin']
```

In [62]:
```
temp_df = pd.DataFrame(selected_df.phone_model.value_counts())
temp_df = temp_df[temp_df.phone_model > 50]
atleast_50_phones = list(temp_df.index)
pprint(atleast_50_phones[:50], compact=True)
```

```
['samsung-galaxy-s6', 'samsung-galaxy-s7-edge', 'apple-iphone-5s',
 'samsung-galaxy-s5', 'motorola-moto-g', 'samsung-galaxy-s7-789999',
 'huawei-p8-lite', 'samsung-i9500-galaxy-s-iv', 'samsung-galaxy-s-iii',
 'lenovo-vibe-k4-note', 'samsung-galaxy-s6-edge-sm-g925f',
 'samsung-galaxy-s4-mini-gt-i9190-gt-i9192-dual-sim', 'oneplus-3',
 'apple-iphone-4s', 'lenovo-vibe-k5', 'lg-g3-d855-657484', 'apple-iphone-6',
 'samsung-galaxy-s3-mini', 'apple-iphone-5', 'lg-g2-594708', 'lg-g4',
 'apple-iphone-4', 'apple-iphone-5c', 'motorola-moto-e',
```

```
'samsung-galaxy-j3-duos', 'samsung-galaxy-note-iii', 'apple-iphone-6s',
'huawei-p9-lite', 'samsung-galaxy-s-ii', 'samsung-s5230',
'samsung-galaxy-note-4', 'samsung-galaxy-s6-edgeplus', 'samsung-galaxy-j5',
'samsung-galaxy-ace-s5830', 'nokia-lumia-520', 'motorola-moto-g3',
'motorola-moto-g4', 'samsung-galaxy-note-2', 'microsoft-lumia-640-dual-sim',
'apple-iphone-7', 'lg-google-nexus-5', 'nokia-5800-xpressmusic-tube',
'google-nexus-5x-h791', 'htc-one-m7', 'nokia-lumia-630',
'samsung-galaxy-a3-2016', 'asus-zenfone-2', 'apple-iphone-se', 'oneplus-3t',
'htc-m8']
```

In [64]:
```
# remove users and phones with less than 50 ratings
train_df = selected_df.copy()
train_df = train_df[train_df.user.isin(atleast_50_users)]
train_df = train_df[train_df.phone_model.isin(atleast_50_phones)]
train_df.sample(7)
```

Out[64]:

	lang	score	review	user	phone_model	year	company
833023	es	8	Gran teléfono, con buena manejabilidad, pantal...	Cliente Amazon	motorola-moto-g	2014-01-01	motorola
367902	en	6	Cheap plastic metal delivered. Anyway phone wa...	Amazon Customer	htc-desire-620g	2015-01-01	htc
618742	en	10	I bought this just after Christmas after seein...	Chris	motorola-xt1225	2017-01-01	motorola
125910	en	2	The cam wasn't working	Amazon Customer	samsung-galaxy-s7-789999	2016-01-01	samsung
863045	en	8	Good mobile, HD screen awsome to watch movies ...	Amazon Customer	motorola-moto-g4	2016-01-01	motorola
863432	en	6	Amazing phone, this saves your time and throws...	Amazon Customer	motorola-moto-g4	2016-01-01	motorola
714098	en	10	Ok lo escribo en español para que quede claro ...	Juan Carlos	blackberry-9630	2009-01-01	blackberry

> Reviews in 21 differente languages,transalte other languages to english to use those reviews

In [65]:
```
len(full_df.lang.value_counts())
```

Out[65]: 20

In [66]:
```
# to translate between languages using multiple models and tools
# !pip install -q -U deep_translator
```

In [67]:
```
from deep_translator import GoogleTranslator
translated = GoogleTranslator(source='auto', target='de').translate("keep it up, you ar
translated
```

Out[67]: 'Weiter so, du bist großartig'

In [68]:
```
# translate reviews to english

%%time
import swifter
from collections import defaultdict
```

```
translators = defaultdict()
languages = list(sampled_df.lang.unique())
languages.remove('en')
pprint(languages, compact=True)

# initialize all the language translators
for lang in languages:
    translators[lang] = GoogleTranslator(source=lang, target='en')

def translate_to_en(row):
    '''translate to english using Google Translator with source from the required colum
    text = row.review
    if row.lang != 'en' and not text.isspace():
        try:
            source = row.lang
            translated = translators[source].translate(text)
            row.review = translated
        except: pass
    row.review_en = text
    return row

# for multiprocessing in pandas apply
# !conda install -c conda-forge swifter
# or
# !pip install swifter

# train_df = train_df.swifter.apply(translate_to_en, axis=1)

# massive ammount of reviews to be translated !!!
# might take atleast a few hours depending on cpu speed
# translated reviews can be used to xtract keywords or to build deep learning models to
```

```
['es', 'nl', 'fr', 'it', 'ru', 'de', 'pt', 'tr', 'fi', 'sv', 'no', 'da', 'he',
 'cs', 'pl', 'hu', 'id', 'ar', 'zh']
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
~\anaconda3\lib\site-packages\swifter\swifter.py in apply(self, func, axis, raw, result_
type, args, **kwds)
    337             with suppress_stdout_stderr():
--> 338                 tmp_df = func(sample, *args, **kwds)
    339                 sample_df = sample.apply(func, axis=axis, raw=raw, result_type=
result_type, args=args, **kwds)

<timed exec> in translate_to_en(row)

~\anaconda3\lib\site-packages\pandas\core\generic.py in __nonzero__(self)
   1328     def __nonzero__(self):
-> 1329         raise ValueError(
   1330             f"The truth value of a {type(self).__name__} is ambiguous. "

ValueError: The truth value of a Series is ambiguous. Use a.empty, a.bool(), a.item(),
 a.any() or a.all().

During handling of the above exception, another exception occurred:

KeyboardInterrupt                         Traceback (most recent call last)
<timed exec> in <module>

~\anaconda3\lib\site-packages\swifter\swifter.py in apply(self, func, axis, raw, result_
type, args, **kwds)
```

```
    365                     apply_func = self._obj.apply
    366
--> 367                 return apply_func(func, axis=axis, raw=raw, result_type=result_
type, args=args, **kwds)
    368
    369     def _wrapped_applymap(self, func):

~\anaconda3\lib\site-packages\tqdm\std.py in inner(df, func, *args, **kwargs)
    795                 # on the df using our wrapper (which provides bar updating)
    796                 try:
--> 797                     return getattr(df, df_function)(wrapper, **kwargs)
    798                 finally:
    799                     t.close()

~\anaconda3\lib\site-packages\pandas\core\frame.py in apply(self, func, axis, raw, resul
t_type, args, **kwds)
   7546             kwds=kwds,
   7547         )
-> 7548         return op.get_result()
   7549
   7550     def applymap(self, func) -> "DataFrame":

~\anaconda3\lib\site-packages\pandas\core\apply.py in get_result(self)
    178             return self.apply_raw()
    179
--> 180         return self.apply_standard()
    181
    182     def apply_empty_result(self):

~\anaconda3\lib\site-packages\pandas\core\apply.py in apply_standard(self)
    269
    270     def apply_standard(self):
--> 271         results, res_index = self.apply_series_generator()
    272
    273         # wrap results

~\anaconda3\lib\site-packages\pandas\core\apply.py in apply_series_generator(self)
    298                 for i, v in enumerate(series_gen):
    299                     # ignore SettingWithCopy here in case the user mutates
--> 300                     results[i] = self.f(v)
    301                     if isinstance(results[i], ABCSeries):
    302                         # If we have a view on v, we need to make a copy because

~\anaconda3\lib\site-packages\tqdm\std.py in wrapper(*args, **kwargs)
    789                     # on the first column/row to decide whether it can
    790                     # take a fast or slow code path; so stop when t.total==t.n
--> 791                     t.update(n=1 if not t.total or t.n < t.total else 0)
    792                     return func(*args, **kwargs)
    793

~\anaconda3\lib\site-packages\tqdm\notebook.py in update(self, *args, **kwargs)
    244     def update(self, *args, **kwargs):
    245         try:
--> 246             return super(tqdm_notebook, self).update(*args, **kwargs)
    247         # NB: except ... [ as ...] breaks IPython async KeyboardInterrupt
    248         except:  # NOQA

~\anaconda3\lib\site-packages\tqdm\std.py in update(self, n)
   1271                             fp_write=getattr(self.fp, 'write', sys.stderr.write))
   1272
-> 1273                 self.refresh(lock_args=self.lock_args)
   1274
   1275                 # If no `miniters` was specified, adjust automatically to the

~\anaconda3\lib\site-packages\tqdm\std.py in refresh(self, nolock, lock_args)
```

```
   1378             else:
   1379                 self._lock.acquire()
-> 1380         self.display()
   1381         if not nolock:
   1382             self._lock.release()

~\anaconda3\lib\site-packages\tqdm\notebook.py in display(self, msg, pos, close, bar_sty
le)
    150 
    151         ltext, pbar, rtext = self.container.children
--> 152         pbar.value = self.n
    153 
    154         if msg:

~\anaconda3\lib\site-packages\traitlets\traitlets.py in __set__(self, obj, value)
    602             raise TraitError('The "%s" trait is read-only.' % self.name)
    603         else:
--> 604             self.set(obj, value)
    605 
    606     def _validate(self, obj, value):

~\anaconda3\lib\site-packages\traitlets\traitlets.py in set(self, obj, value)
    591             # we explicitly compare silent to True just in case the equality
    592             # comparison above returns something other than True/False
--> 593             obj._notify_trait(self.name, old_value, new_value)
    594 
    595     def __set__(self, obj, value):

~\anaconda3\lib\site-packages\traitlets\traitlets.py in _notify_trait(self, name, old_va
lue, new_value)
   1215 
   1216     def _notify_trait(self, name, old_value, new_value):
-> 1217         self.notify_change(Bunch(
   1218             name=name,
   1219             old=old_value,

~\anaconda3\lib\site-packages\ipywidgets\widgets\widget.py in notify_change(self, chang
e)
    603             if name in self.keys and self._should_send_property(name, getattr(s
elf, name)):
    604                 # Send new state to front-end
--> 605                 self.send_state(key=name)
    606         super(Widget, self).notify_change(change)
    607 

~\anaconda3\lib\site-packages\ipywidgets\widgets\widget.py in send_state(self, key)
    487             state, buffer_paths, buffers = _remove_buffers(state)
    488             msg = {'method': 'update', 'state': state, 'buffer_paths': buffer_p
aths}
--> 489             self._send(msg, buffers=buffers)
    490 
    491 

~\anaconda3\lib\site-packages\ipywidgets\widgets\widget.py in _send(self, msg, buffers)
    735         """Sends a message to the model in the front-end."""
    736         if self.comm is not None and self.comm.kernel is not None:
--> 737             self.comm.send(data=msg, buffers=buffers)
    738 
    739     def _repr_keys(self):

~\anaconda3\lib\site-packages\ipykernel\comm\comm.py in send(self, data, metadata, buffe
rs)
    120     def send(self, data=None, metadata=None, buffers=None):
    121         """Send a message to the frontend-side version of this comm"""
--> 122         self._publish_msg('comm_msg',
```

```
    123             data=data, metadata=metadata, buffers=buffers,
    124         )

~\anaconda3\lib\site-packages\ipykernel\comm\comm.py in _publish_msg(self, msg_type, dat
a, metadata, buffers, **keys)
     64         metadata = {} if metadata is None else metadata
     65         content = json_clean(dict(data=data, comm_id=self.comm_id, **keys))
---> 66         self.kernel.session.send(self.kernel.iopub_socket, msg_type,
     67             content,
     68             metadata=json_clean(metadata),

~\anaconda3\lib\site-packages\jupyter_client\session.py in send(self, stream, msg_or_typ
e, content, parent, ident, buffers, track, header, metadata)
    749             # use dummy tracker, which will be done immediately
    750             tracker = DONE
--> 751             stream.send_multipart(to_send, copy=copy)
    752 
    753         if self.debug:

~\anaconda3\lib\site-packages\ipykernel\iostream.py in send_multipart(self, *args, **kwa
rgs)
    262     def send_multipart(self, *args, **kwargs):
    263         """Schedule send in IO thread"""
--> 264         return self.io_thread.send_multipart(*args, **kwargs)
    265 
    266 

~\anaconda3\lib\site-packages\ipykernel\iostream.py in send_multipart(self, *args, **kwa
rgs)
    212         If my thread isn't running (e.g. forked process), send immediately.
    213         """
--> 214         self.schedule(lambda : self._really_send(*args, **kwargs))
    215 
    216     def _really_send(self, msg, *args, **kwargs):

~\anaconda3\lib\site-packages\ipykernel\iostream.py in schedule(self, f)
    203             self._events.append(f)
    204             # wake event thread (message content is ignored)
--> 205             self._event_pipe.send(b'')
    206         else:
    207             f()

~\anaconda3\lib\site-packages\zmq\sugar\socket.py in send(self, data, flags, copy, trac
k, routing_id, group)
    414                                     copy_threshold=self.copy_threshold)
    415             data.group = group
--> 416         return super(Socket, self).send(data, flags=flags, copy=copy, track=tra
ck)
    417 
    418     def send_multipart(self, msg_parts, flags=0, copy=True, track=False, **kwar
gs):

zmq/backend/cython/socket.pyx in zmq.backend.cython.socket.Socket.send()

zmq/backend/cython/socket.pyx in zmq.backend.cython.socket.Socket.send()

zmq/backend/cython/socket.pyx in zmq.backend.cython.socket._send_copy()

~\anaconda3\lib\site-packages\zmq\backend\cython\checkrc.pxd in zmq.backend.cython.check
rc._check_rc()

KeyboardInterrupt:
```

In [69]:
```
train_df.shape # final shape of dataframe
```

Out[69]: (173473, 7)

3. Build a popularity based model and recommend top 5 mobile phones

In [71]:
```
train_df.groupby('phone_model')['score'].mean().sort_values(ascending=False).head(20)
```

Out[71]:
```
phone_model
nokia-5700-xpressmusic               10.0
samsung-sgh-e200                     10.0
lenovo-p700i                         10.0
lg-200                               10.0
samsung-galaxy-s-iii-slim-sm-g3812   10.0
lg-gm205                             10.0
nokia-9300                           10.0
lg-kf700                             10.0
samsung-e1120                        10.0
meizu-mx2                            10.0
motorola-c115                        10.0
prestigio-multiphone-4500            10.0
motorola-moto-q-global               10.0
philips-xenium-x518                  10.0
motorola-w220                        10.0
motorola-w375                        10.0
mysaga-c2                            10.0
nokia-1209                           10.0
nokia-3100                           10.0
palm-treo-650                        10.0
Name: score, dtype: float64
```

In [73]:
```
train_df.groupby('phone_model')['score'].count().sort_values(ascending=False).head(20)
# doesn't consider no. of ratings for each phone and the mean of ratings might be affec
# might give unintuitive recommendations
```

Out[73]:
```
phone_model
lenovo-vibe-k4-note          4639
lenovo-vibe-k5               4059
apple-iphone-5s              3035
oneplus-3                    3028
huawei-p8-lite               2928
samsung-galaxy-s7-edge       2739
motorola-moto-g              2306
samsung-galaxy-s7-789999     2051
motorola-moto-g4             1902
samsung-galaxy-s5            1843
huawei-p9-lite               1788
apple-iphone-6               1661
samsung-galaxy-s6            1515
motorola-moto-g3             1494
lenovo-zuk-z1                1474
samsung-i9500-galaxy-s-iv    1403
oneplus-3t                   1348
lg-g3-d855-657484            1290
apple-iphone-6s              1281
lg-g4                        1203
Name: score, dtype: int64
```

In [74]:
```
# Get the top 5 recommendations
popularity_recommendations = train_df.groupby('phone_model')['score'].mean().sort_value
popularity_recommendations
```

Out[74]:
```
phone_model
```

```
nokia-5700-xpressmusic                10.0
samsung-sgh-e200                      10.0
lenovo-p700i                          10.0
lg-200                                10.0
samsung-galaxy-s-iii-slim-sm-g3812    10.0
Name: score, dtype: float64
```

> Hence, we recommend the top 5 phones from the above table using a simple popularity based model

In [77]:
```
# to build a smarter popularity recommendation model
# get weighted scores

train_df_copy = train_df.copy()
train_len = len(train_df_copy)
def rating_by_count(row):
    score = row.score
    weight = train_df_copy[train_df_copy.score == score].shape[0]/train_len
    row['rating_by_count'] = score * weight
    return row

train_df = train_df.swifter.apply(rating_by_count, axis=1)
```

In [80]:
```
train_df
```

Out[80]:

	lang	score	review	user	phone_model	year	company
2	nl	9	Met deze telefoon heb ik gewoon een volwaardig...	Jerry	sony-xperia-z5	2016-01-01	sony
5	en	2	Worst phone working. Always keep hanging	Amazon Customer	asus-zenfone-max-zc550kl	2016-01-01	asus
8	it	8	Sono molto soddisfatto. Prima esperienza con i...	Gustavo	huawei-honor-7	2016-01-01	huawei
26	pt	10	Gostei de todos os aspectos do aparelho, só o ...	e-bit	samsung-galaxy-a5-2016	2016-01-01	samsung
28	it	10	L'ho preso in offerta lampo e devo dire che pe...	Alias	cubot-x16	2016-01-01	cubot
...	...	...	...	...	...	...	...
999980	es	10	Es un excelente móvil, a un precio asequible y...	Cliente Amazon	asus-zenfone-2-ze551ml	2015-01-01	asus
999982	en	2	Very very badly experience Moto g turbo. reall...	Amazon Customer	motorola-moto-g-turbo-edition	2016-01-01	motorola
999990	es	10	Hasta el.momento el teléfono va de maravillas....	Martin	asus-zenfone-2	2015-01-01	asus
999992	it	10	ottimo relativamente al prezzo. Sono soddisfat...	angelo	sony-ericsson-xperia-x8	2013-01-01	sony
999996	en	10	No complaints about the phone does exactly wha...	Kindle Customer	htc-one-m7	2013-01-01	htc

173473 rows × 7 columns

In [79]:
```
# Get the top 5 recommendations
popularity_recommendations = train_df.groupby('phone_model')['rating_by_count'].mean().
popularity_recommendations
```

```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
<ipython-input-79-8de6cb6bf295> in <module>
      1 # Get the top 5 recommendations
----> 2 popularity_recommendations = train_df.groupby('phone_model')['rating_by_count']
.mean().sort_values(ascending=False).head(5)
      3 popularity_recommendations

~\anaconda3\lib\site-packages\pandas\core\groupby\generic.py in __getitem__(self, key)
   1648                 stacklevel=2,
   1649             )
-> 1650         return super().__getitem__(key)
   1651
   1652     def _gotitem(self, key, ndim: int, subset=None):

~\anaconda3\lib\site-packages\pandas\core\base.py in __getitem__(self, key)
    226         else:
    227             if key not in self.obj:
--> 228                 raise KeyError(f"Column not found: {key}")
    229             return self._gotitem(key, ndim=1)
    230

KeyError: 'Column not found: rating_by_count'
```

4. Build a collaborative filtering model using SVD: Both user-based and item-based nearest neighbor models.

5. Evaluate the collaborative model | RMSE

In [84]:
```
from surprise import SVD, KNNWithMeans
from surprise import accuracy
from surprise import Dataset,Reader
from surprise.model_selection import GridSearchCV
```

In [86]:
```
reader = Reader(rating_scale=(1, 10))
data = Dataset.load_from_df(train_df[['user', 'phone_model', 'score']], reader)
```

In [87]:
```
from surprise.model_selection import train_test_split
trainset, testset = train_test_split(data, test_size=.25,random_state=123)
models = defaultdict(dict)
```

SVD

In [91]:
```
svd_model = SVD(n_factors=50,biased=False)
svd_model.fit(trainset)
```

Out[91]:
```
<surprise.prediction_algorithms.matrix_factorization.SVD at 0x1556e8a6970>
```

In [92]:
```
test_pred = svd_model.test(testset)
```

In [93]:
```
# compute RMSE
rmse = accuracy.rmse(test_pred)
model = 'Collaborative Filtering with SVD'
```

```
models[model]['name'] = model
models[model]['rmse'] = rmse

pprint(models[model])
```

```
RMSE: 2.8784
{'name': 'Collaborative Filtering with SVD', 'rmse': 2.87841290868112}
```

KNNWithMeans

In [94]:
```
colab_i = KNNWithMeans(k=10, sim_options={ 'user_based': False})
colab_i.fit(trainset)
```

```
Computing the msd similarity matrix...
Done computing similarity matrix.
```

Out[94]:
```
<surprise.prediction_algorithms.knns.KNNWithMeans at 0x1556e8a6070>
```

In [96]:
```
test_pred=colab_i.test(testset)
# compute RMSE
rmse = accuracy.rmse(test_pred)
model = 'Item-Based Collaborative Filtering with KNNMeans'
models[model]['name'] = model
models[model]['rmse'] = rmse

pprint(models[model])
```

```
RMSE: 2.8747
{'name': 'Item-Based Collaborative Filtering with KNNMeans',
 'rmse': 2.8747228816219894}
```

In [97]:
```
colab_u = KNNWithMeans(k=10, sim_options={ 'user_based': True})
colab_u.fit(trainset)
```

```
Computing the msd similarity matrix...
Done computing similarity matrix.
```

Out[97]:
```
<surprise.prediction_algorithms.knns.KNNWithMeans at 0x1556d3748b0>
```

In [98]:
```
test_pred=colab_u.test(testset)
rmse = accuracy.rmse(test_pred)
model = 'User-Based Collaborative Filtering with KNNMeans'
models[model]['name'] = model
models[model]['rmse'] = rmse

pprint(models[model])
```

```
RMSE: 2.8581
{'name': 'User-Based Collaborative Filtering with KNNMeans',
 'rmse': 2.8581296574638904}
```

Cross Validate

In [102…
```
from surprise.model_selection import cross_validate
cross_validate(colab_i, data, measures=['RMSE'], cv=3, verbose=True)
```

```
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Evaluating RMSE of algorithm KNNWithMeans on 3 split(s).
```

```
                  Fold 1  Fold 2  Fold 3  Mean    Std
RMSE (testset)    2.8853  2.8920  2.8835  2.8869  0.0037
Fit time          113.67  107.24  102.92  107.94  4.42
Test time         442.54  463.02  454.38  453.31  8.40
```

Out[102…
```
{'test_rmse': array([2.88527295, 2.89202891, 2.88352489]),
 'fit_time': (113.67019534111023, 107.24300146102905, 102.92000031471252),
 'test_time': (442.5410006046295, 463.02340722084045, 454.3752930164337)}
```

In [103…
```
test_pred=colab_i.test(testset)
rmse = accuracy.rmse(test_pred)
model = 'Cross-Val Item-Based Collaborative Filtering with KNNMeans'
models[model]['name'] = model
models[model]['rmse'] = rmse

pprint(models[model])
```

```
RMSE: 2.5650
{'name': 'Cross-Val Item-Based Collaborative Filtering with KNNMeans',
 'rmse': 2.565016622858161}
```

In [104…
```
cross_validate(colab_u, data, measures=['RMSE'], cv=3, verbose=True)
```

```
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Evaluating RMSE of algorithm KNNWithMeans on 3 split(s).

                  Fold 1  Fold 2  Fold 3  Mean    Std
RMSE (testset)    2.8673  2.8694  2.8850  2.8739  0.0079
Fit time          19.08   3.80    3.71    8.87    7.22
Test time         18.66   17.43   16.79   17.62   0.78
```

Out[104…
```
{'test_rmse': array([2.86733611, 2.86935931, 2.8849863 ]),
 'fit_time': (19.079009294509888, 3.8040008544921875, 3.712999105453491),
 'test_time': (18.657991409301758, 17.426000356674194, 16.786999464035034)}
```

In [105…
```
test_pred=colab_u.test(testset)
rmse = accuracy.rmse(test_pred)
model = 'Cross-Val User-Based Collaborative Filtering with KNNMeans'
models[model]['name'] = model
models[model]['rmse'] = rmse

pprint(models[model])
```

```
RMSE: 2.5824
{'name': 'Cross-Val User-Based Collaborative Filtering with KNNMeans',
 'rmse': 2.5824077993259205}
```

6. Predict score (average rating) for test users

In [106…
```
# run the trained model against the testset
test_pred = colab_u.test(testset)
```

In [107…
```
test_pred
```

Out[107…
```
[Prediction(uid='Sergio', iid='microsoft-lumia-640-dual-sim', r_ui=10.0, est=9.489876678
847773, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='oneplus-3', r_ui=8.0, est=8.6, details={'actual_
k': 10, 'was_impossible': False}),
```

```
 Prediction(uid='Kindle Customer', iid='samsung-galaxy-s-iii', r_ui=8.0, est=7.644868456
292452, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='alcatel-onetouch-20-04', r_ui=2.0, est=8.0, detai
ls={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='motorola-moto-g-turbo-edition', r_ui=6.0, est=5.
8, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Daniele', iid='huawei-p9-lite', r_ui=8.0, est=9.126363636842019, detail
s={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Ольга', iid='nokia-101', r_ui=10.0, est=9.357954504254739, details={'ac
tual_k': 10, 'was_impossible': False}),
 Prediction(uid='Alex', iid='samsung-galaxy-y-s5360', r_ui=6.0, est=7.264266780978673, d
etails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='asus-zenfone-3-max', r_ui=6.0, est=7.0, details=
{'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='einem Kunden', iid='zte-blade-a452', r_ui=10.0, est=7.6, details={'actu
al_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Kunde', iid='huawei-p8-lite', r_ui=10.0, est=7.2, details={'actu
al_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='samsung-galaxy-j7', r_ui=10.0, est=6.4, details=
{'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='sony-xperia-z1', r_ui=8.0, est=7.239575527146138,
details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='apple-iphone-6', r_ui=2.0, est=5.4, details={'ac
tual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='google-nexus-6p', r_ui=10.0, est=8.2, details=
{'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='ttfone-venus-2', r_ui=10.0, est=8.2, details={'a
ctual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='huawei-honor-8', r_ui=10.0, est=7.4, details={'a
ctual_k': 10, 'was_impossible': False}),
 Prediction(uid='Anonymous', iid='samsung-galaxy-ace-s5830', r_ui=8.0, est=8.20639952052
0641, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Julian', iid='microsoft-lumia-535', r_ui=4.0, est=2.877825190211346, de
tails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='microsoft-lumia-640-dual-sim', r_ui=8.0, est=7.8,
details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='huawei-p8-lite-2017', r_ui=8.0, est=9.4, details=
{'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Filippo', iid='microsoft-lumia-535', r_ui=10.0, est=9.884395788518892,
details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='lenovo-vibe-k5', r_ui=4.0, est=4.80000000000000
1, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Anónimo ', iid='lg-g3-d855-657484', r_ui=10.0, est=9.2, details={'actua
l_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='google-nexus-5x-h791', r_ui=10.0, est=8.6, detail
s={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Danilo', iid='samsung-gt-e1200', r_ui=10.0, est=9.609686941076852, deta
ils={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Stefano', iid='nokia-101', r_ui=6.0, est=9.025857889299262, details={'a
ctual_k': 10, 'was_impossible': False}),
 Prediction(uid='einem Kunden', iid='zte-blade-a452', r_ui=10.0, est=7.6, details={'actu
al_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='cubot-gt72', r_ui=10.0, est=8.263888033318844, d
etails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='�лек�андр', iid='nokia-x6', r_ui=10.0, est=6.726110373616406, details
={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='giuseppe', iid='lg-g2-mini', r_ui=10.0, est=9.194825112148884, details=
{'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Wolfgang', iid='lg-g3-d855-657484', r_ui=8.0, est=6.612222492309586, de
tails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Jose Luis', iid='sony-xperia-z2', r_ui=10.0, est=9.737307448886398, det
ails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='e-bit', iid='lg-k10', r_ui=10.0, est=8.2, details={'actual_k': 10, 'was
_impossible': False}),
 Prediction(uid='Alex', iid='samsung-galaxy-s7-edge', r_ui=8.0, est=9.429317931025594, d
```

```
etails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='lenovo-vibe-k5', r_ui=6.0, est=4.800000000000001, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='MM', iid='nokia-c2-01', r_ui=6.0, est=7.111863874576956, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='e-bit', iid='sony-xperia-m2-aqua-d2403', r_ui=10.0, est=8.8, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='ulefone-paris', r_ui=10.0, est=7.8, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='roberto', iid='lg-e450-optimus-l5-ii', r_ui=10.0, est=9.56358040089213, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Benjamin', iid='cubot-one', r_ui=8.0, est=8.438973435958058, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='nokia-asha-230', r_ui=10.0, est=7.6, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='wileyfox-swift', r_ui=10.0, est=8.2, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='lenovo-vibe-k4-note', r_ui=6.0, est=8.8, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='motorola-moto-z-droid', r_ui=4.0, est=8.262817169731111, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='samsung-gusto-2', r_ui=2.0, est=5.186801032865603, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='doogee-voyager2-dg310', r_ui=10.0, est=7.6, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Vijay', iid='htc-one-x9', r_ui=2.0, est=7.942382569432254, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='oneplus-3', r_ui=2.0, est=8.6, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='einem Kunden', iid='sony-xperia-xa', r_ui=10.0, est=8.8, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Richard', iid='lg-g2-594708', r_ui=4.0, est=4.261237204042818, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid="Client d'Amazon", iid='htc-10', r_ui=10.0, est=8.499027758733249, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Alberto', iid='motorola-moto-x', r_ui=10.0, est=9.243638362938032, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='meizu-m3-note', r_ui=10.0, est=8.6, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Stefano', iid='huawei-p9-lite', r_ui=10.0, est=9.29506533645911, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='huawei-ascend-mate-7', r_ui=2.0, est=8.6, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Rick', iid='samsung-galaxy-note-4', r_ui=6.0, est=7.824921871377972, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Михаил', iid='nokia-lumia-930', r_ui=6.0, est=7.989825592960896, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='nokia-2720-fold', r_ui=8.0, est=7.04147829038523, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='motorola-moto-g-turbo-edition', r_ui=10.0, est=5.8, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Matteo', iid='sony-xperia-l', r_ui=10.0, est=9.305661975490159, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Victor', iid='lg-g4c', r_ui=4.0, est=5.4712780140732225, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='lenovo-vibe-k5', r_ui=4.0, est=4.800000000000001, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Daniel', iid='sony-ericsson-w880i', r_ui=6.0, est=6.990935202053801, details={'actual_k': 8, 'was_impossible': False}),
 Prediction(uid='Daniele', iid='samsung-galaxy-s-iii-neo-i9300i', r_ui=10.0, est=9.743603238786362, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='asus-zenfone-max-zc550kl', r_ui=8.0, est=7.4, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='vivo-v5', r_ui=10.0, est=7.8, details={'actual_k': 10, 'was_impossible': False}),
```

```
 Prediction(uid='Gustavo', iid='google-nexus-5x-h791', r_ui=8.0, est=9.290438623065816,
details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='apple-iphone-5', r_ui=10.0, est=5.80000000000000
1, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='einer Kundin', iid='samsung-galaxy-s7-edge', r_ui=10.0, est=9.6, detail
s={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Cliente Amazon', iid='doogee-x6-pro', r_ui=10.0, est=7.2, details={'act
ual_k': 10, 'was_impossible': False}),
 Prediction(uid='�лек�ей', iid='lg-gx500', r_ui=8.0, est=7.927146739469582, details=
{'actual_k': 5, 'was_impossible': False}),
 Prediction(uid='Flo', iid='samsung-galaxy-nexus', r_ui=10.0, est=9.480749810818043, det
ails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='lenovo-vibe-x3', r_ui=8.0, est=7.4, details={'ac
tual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='lenovo-vibe-k5', r_ui=10.0, est=4.80000000000000
1, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='samsung-galaxy-core-prime', r_ui=2.0, est=4.4000
00000000001, details={'actual_k': 10, 'was_impossible': False}),
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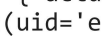

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etails={'actual_k': 10, 'was_impossible': False}),
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1, details={'actual_k': 10, 'was_impossible': False}),
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 Prediction(uid='Amazon Customer', iid='lenovo-vibe-k5', r_ui=8.0, est=4.80000000000000
```

```
1, details={'actual_k': 10, 'was_impossible': False}),
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tails={'actual_k': 6, 'was_impossible': False}),
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etails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='asus-zenfone-max-zc550kl', r_ui=10.0, est=7.4, d
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```

```
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ls={'actual_k': 10, 'was_impossible': False}),
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etails={'actual_k': 10, 'was_impossible': False}),
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details={'actual_k': 10, 'was_impossible': False}),
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3, details={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='oneplus-3', r_ui=10.0, est=8.6, details={'actual
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etails={'actual_k': 10, 'was_impossible': False}),
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1, details={'actual_k': 10, 'was_impossible': False}),
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ctual_k': 10, 'was_impossible': False}),
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ils={'actual_k': 10, 'was_impossible': False}),
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```

```
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41, details={'actual_k': 10, 'was_impossible': False}),
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al_k': 10, 'was_impossible': False}),
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ctual_k': 10, 'was_impossible': False}),
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_k': 10, 'was_impossible': False}),
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ual_k': 10, 'was_impossible': False}),
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etails={'actual_k': 10, 'was_impossible': False}),
 Prediction(uid='Amazon Customer', iid='motorola-moto-g3', r_ui=2.0, est=6.8, details=
{'actual_k': 10, 'was_impossible': False}),
 ...]
```

7. Report your findings and inferences.

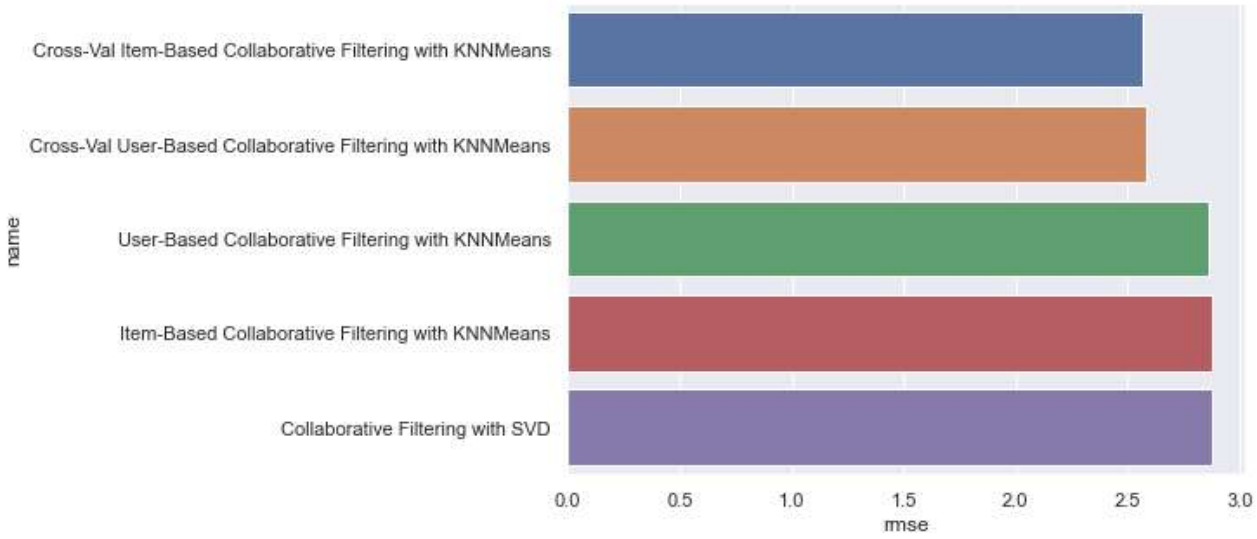
In [110…
```
model_results = pd.DataFrame(dict(models)).T.sort_values(by=['rmse'], ascending = [True
model_results.set_index('name')
model_results
```

Out[110…

	name	rmse
Cross-Val Item-Based Collaborative Filtering with KNNMeans	Cross-Val Item-Based Collaborative Filtering w...	2.56502
Cross-Val User-Based Collaborative Filtering with KNNMeans	Cross-Val User-Based Collaborative Filtering w...	2.58241

	name	rmse
User-Based Collaborative Filtering with KNNMeans	User-Based Collaborative Filtering with KNNMeans	2.85813
Item-Based Collaborative Filtering with KNNMeans	Item-Based Collaborative Filtering with KNNMeans	2.87472
Collaborative Filtering with SVD	Collaborative Filtering with SVD	2.87841

In [111…
```
sns.set()
plt.figure(figsize=(7,5))
sns.barplot(x = "rmse", y = "name", data = model_results)
plt.show()
```



> The best models seem to be Item-based and User-Based Collaborative filtering with KNNMeans fit with cross validation

8. Try and recommend top 5 products for test users

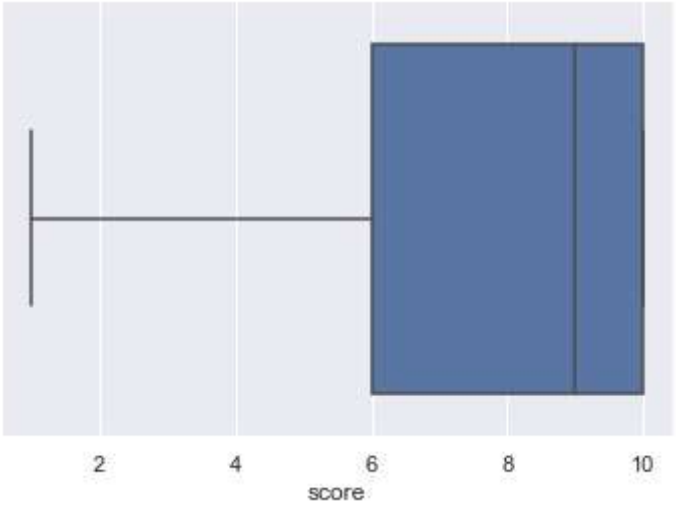
In [182…
```
# Top 5 recommendations for a sample test user
pred = pd.DataFrame(test_pred)
for uid in pred['uid'].sample():
    print(uid)
    print(pred[pred['uid'] == 'Simon'][['iid', 'r_ui','est']].sort_values(by = 'est', a
    print()
```

```
Cliente Amazon
                          iid  r_ui       est
13836  samsung-galaxy-note-iii  10.0  9.684642
10212         samsung-gt-e1200   8.0  9.680418
42707         acer-cloudmobile  10.0  9.582443
11776    motorola-photon-q-lte  10.0  9.547781
35579          motorola-moto-g  10.0  9.358828
```

9. Check for outliers and impute them as required

In [185…
```
sns.boxplot(train_df.score)
```

Out[185… <AxesSubplot:xlabel='score'>



In [186…
```
q1 = train_df['score'].quantile(0.25) #first quartile value
q3 = train_df['score'].quantile(0.75) # third quartile value
iqr = q3-q1 #Interquartile range
low  = q1-1.5*iqr #acceptable range
high = q3+1.5*iqr #acceptable range
low, high, iqr
```

Out[186… (0.0, 16.0, 4.0)

In [187…
```
# imputation by capping technique | replace outliers with whiskers
train_df.loc[train_df["score"] < low, "score"] = low
train_df.loc[train_df["score"] > high, "score"] = high
```

11. In what business scenario you should use popularity based Recommendation Systems ?

> • Recommend products rated high by all users.
> • It works without having information on the user.
> • It's not personalized for specific users, It uses a simple frequency based recommendations.
> • A common approach is to use collaborative filtering whenver we have enough data to avoid cold-start and grey-sheep problems and fall-back to a simple popularity based recommendation system whenever such a problem is there or when we have no data on the current user.

12. In what business scenario you should use CF based Recommendation Systems ?

> • Recommend products rated high by users similar to current users (user-based) or items rated similar to current item (item-based)
> • It doesn't require any information about the users or the content of the review ..etc., Only the ratings given by other users for the items is sufficient
> • Might show you unrelated products if you do it a high-level all-products at once.
> • Suffers from cold-start and grey-sheep problem • Cold-start: New products or new users with no ratings or history columns or rows →

> Use a hybrid approach with fall-back to content-based reccomendation system
> • Grey-sheep problem: One or two ratings for a few products, but none else in the crowd, rated them highly. No neighbours to find -> Switch to popularity based or content-based for the specific user...
> • Content-based models can be used to solve the Cold Start and Gray Sheep problems in Collaborative Filtering
> • Have to do it a category-level, sub-category level granularity
> • de-mean the item rating data to remove item bias
> • Generally both user-based and item-based are used to give recommendations
> • A common approach is to use collaborative filtering whenver we have enough data to avoid cold-start and grey-sheep problems and use content-based recommendation when we don't have data on user but have enough information on the product (description, reviews...) and fall-back to a simple popularity based recommendation system whenever such a problem is there or when we have no data on the current user.

13. What other possible methods can you think of which can further improve the recommendation for different users

> • Deep Learning based models: LSTMS, BiLSTMS (with Bidirection Context), Transformers, BERT .. will be much more effective to learn about sentiment from the reviews using various word embeddings. Several libraries like flair, HuggingFace, keras could be used to build review rating classfifiers.
> • Preprocessing of reviews will help the content based models learn a lot better by stripping stop words, removing puncutation, extracting keywords ... etc.,
> • Using a Hybrid model with various techniques will almost always yield better results.
> • A common approach is to use Latent Factor models for high-level recommendation and then improving them using content-based systems by using the information on users or item