Google-Play-Store-App-Downloads

Prediction of number of App downloads from Google Play Store using Machine Learning.

Model Scenario : Google play store is the hub to download all the apps on the device whether it is a laptop or mobile phone. When we download app from google play store, on screen page some sort of information's like reviews, ratings, type of app in playstore etc characteristics are there.

Objective : By using different ML algorithms, we have to predict total number of downloads of a particular app from google play store. We have to predict the total number of downloads based on different features.

Double-click (or enter) to edit

Business Scope of the project:

This project will be helpful for app developers and marketing teams to predict the number of downloads for an app on the Google Play Store. This can help them to optimizetheir app development and marketing strategies to improve the visibility and popularity of theirapps, which can ultimately lead to more downloads and revenue.

Approach:

Based on the available dataset and problem statement, we can use regression models such as Linear Regression, Ridge Regression, Lasso Regression, Decision Tree Regression, Random Forest Regression, Gradient, Extreme Gradient and Ada Boost Regression to predict the total number of downloads of an app on the Google Play Store. Alsosince the target variable has limited unique data and is in the form of discrete classes, we will bin the data of the target variable into classes and use classification models like Decision Tree Clasifier, Random Forest Classifier, Gradient Boost classifier to check its accuracy.

Tasks Performed and Outcome:

1) First the data is thoroughly analysed and EDA is performed. In this Data Preprocessing part, the null values are checked and treated, Box Plots created to find outliers. Extreme values are not dropped in this dataset as replacing them with mean, median for this particular data set made little sense.

2) To check for multicollinearity, we used heat map and variance inflation factor (VIF). If multicollinearity is present, we can remove one of the highly correlated features or use

dimensionality reduction techniques such as Principal Component Analysis (PCA). In this dataset we removed the 'Rating' feature which showed a high VIF number. Removing it helped to prevent overfitting in the Regression Model Building part. The Classification Models however showed signs of over fitting.

3) The model requires scaling. We have used log transformation and also used Normalisation technique for scaling certain features.

4) The Regression models were built be evaluated using various evaluation parameters such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), R-squared (R2). The Classification Models were evaluated using parameters like Accuracy Score. Based on these parameters, we can select the best-performing model. The best performing models from Regression and Classification were chosen and further trained and tuned with hyper parameters to futher improve their performance.

```
# Data Manipulation and Handling libraries
import pandas as pd
import numpy as np

#data visualization libraries
import matplotlib.pyplot as plt
import seaborn as sns

# Regular Expression
import re

# Preprocessing Libraries
from sklearn.preprocessing import MinMaxScaler

## Multicollinearity Test Libraries
from statsmodels.stats.outliers_influence import variance_inflation_factor

# Model selection Libraries
from sklearn.model_selection import train_test_split , cross_val_score, KFold, GridSearchC

#ML Models
from sklearn.linear_model import LinearRegression , Lasso , Ridge
from sklearn.tree import DecisionTreeRegressor
from sklearn.svm import SVR
from sklearn.neighbors import KNeighborsRegressor
from sklearn.ensemble import RandomForestRegressor, AdaBoostRegressor, GradientBoostingReg
import xgboost
from xgboost import XGBRegressor
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC

# Model Evaluation Libraries
from sklearn.metrics import r2_score, mean_squared_error
from sklearn.metrics import accuracy_score
```

Loading the dataset

```
playstore = pd.read_csv('googleplaystore.csv') # importing data set and creating a copy of
```

```
df = playstore.copy()
```

```
df.head()
```

	App	Category	Rating	Reviews	Size	Installs	Type	Price	Cont Rat
0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19M	10,000+	Free	0	Every
1	Coloring book moana	ART_AND_DESIGN	3.9	967	14M	500,000+	Free	0	Every
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8.7M	5,000,000+	Free	0	Every
	Sketch -								

EDA

```
df.shape
```

```
(10841, 13)
```

```
df.nunique()
```

```
App              9660
Category           34
Rating             40
Reviews          6002
Size              462
Installs           22
```

```
Type                 3
Price               93
Content Rating       6
Genres             120
Last Updated      1378
Current Ver       2784
Android Ver         33
dtype: int64
```

```
df.info() # lots of numerical features are classifies as object. Treatment required
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10841 entries, 0 to 10840
Data columns (total 13 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   App             10841 non-null  object 
 1   Category        10841 non-null  object 
 2   Rating          9367 non-null   float64
 3   Reviews         10841 non-null  object 
 4   Size            10841 non-null  object 
 5   Installs        10841 non-null  object 
 6   Type            10840 non-null  object 
 7   Price           10841 non-null  object 
 8   Content Rating  10840 non-null  object 
 9   Genres          10841 non-null  object 
 10  Last Updated    10841 non-null  object 
 11  Current Ver     10833 non-null  object 
 12  Android Ver     10838 non-null  object 
dtypes: float64(1), object(12)
memory usage: 1.1+ MB
```

```
df.isnull().sum()
```

```
App                  0
Category             0
Rating            1474
Reviews              0
Size                 0
Installs             0
Type                 1
Price                0
Content Rating       1
Genres               0
Last Updated         0
Current Ver          8
Android Ver          3
dtype: int64
```

```
print(df.isnull().sum()/len(df)*100) # Missing values needs to be treated.
```

```
App                0.000000
Category           0.000000
Rating            13.596532
Reviews            0.000000
Size               0.000000
Installs           0.000000
```

```
     Type              0.009224
     Price             0.000000
     Content Rating    0.009224
     Genres            0.000000
     Last Updated      0.000000
     Current Ver       0.073794
     Android Ver       0.027673
     dtype: float64
```

```
df['Reviews'].unique()
```

```
     array(['159', '967', '87510', ..., '603', '1195', '398307'], dtype=object)
```

```
df.loc[10472]
```

```
     App               Life Made WI-Fi Touchscreen Photo Frame
     Category                                              1.9
     Rating                                               19.0
     Reviews                                              3.0M
     Size                                               1,000+
     Installs                                             Free
     Type                                                    0
     Price                                            Everyone
     Content Rating                                        NaN
     Genres                                          11-Feb-18
     Last Updated                                       1.0.19
     Current Ver                                    4.0 and up
     Android Ver                                           NaN
     Name: 10472, dtype: object
```

```
df['Reviews'] = df['Reviews'].str.replace('3.0M', '3000000')
```

```
     <ipython-input-12-299729241386>:1: FutureWarning: The default value of regex will cha
       df['Reviews'] = df['Reviews'].str.replace('3.0M', '3000000')
```

```
df.loc[10472]
```

```
     App               Life Made WI-Fi Touchscreen Photo Frame
     Category                                              1.9
     Rating                                               19.0
     Reviews                                           3000000
     Size                                               1,000+
     Installs                                             Free
     Type                                                    0
     Price                                            Everyone
     Content Rating                                        NaN
     Genres                                          11-Feb-18
     Last Updated                                       1.0.19
     Current Ver                                    4.0 and up
     Android Ver                                           NaN
     Name: 10472, dtype: object
```

```
df['Reviews']= pd.to_numeric(df['Reviews'])
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10841 entries, 0 to 10840
Data columns (total 13 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   App             10841 non-null  object 
 1   Category        10841 non-null  object 
 2   Rating          9367 non-null   float64
 3   Reviews         10841 non-null  int64  
 4   Size            10841 non-null  object 
 5   Installs        10841 non-null  object 
 6   Type            10840 non-null  object 
 7   Price           10841 non-null  object 
 8   Content Rating  10840 non-null  object 
 9   Genres          10841 non-null  object 
 10  Last Updated    10841 non-null  object 
 11  Current Ver     10833 non-null  object 
 12  Android Ver     10838 non-null  object 
dtypes: float64(1), int64(1), object(11)
memory usage: 1.1+ MB
```

```
df['Installs'].unique()
```

```
array(['10,000+', '500,000+', '5,000,000+', '50,000,000+', '100,000+',
       '50,000+', '1,000,000+', '10,000,000+', '5,000+', '100,000,000+',
       '1,000,000,000+', '1,000+', '500,000,000+', '50+', '100+', '500+',
       '10+', '1+', '5+', '0+', '0', 'Free'], dtype=object)
```

```
x = df[df['Installs']== 'Free']
x
```

	App	Category	Rating	Reviews	Size	Installs	Type	Price	Cont Rat
10472	Life Made WI-Fi Touchscreen Photo Frame	1.9	19.0	3000000	1,000+	Free	0	Everyone	N

```
df = df.drop([10472], axis = 0)
```

```
df['Installs'].unique()
```

```
array(['10,000+', '500,000+', '5,000,000+', '50,000,000+', '100,000+',
       '50,000+', '1,000,000+', '10,000,000+', '5,000+', '100,000,000+',
       '1,000,000,000+', '1,000+', '500,000,000+', '50+', '100+', '500+',
       '10+', '1+', '5+', '0+', '0'], dtype=object)
```

```
df['Price'].unique()
```

```
array(['0', '$4.99 ', '$3.99 ', '$6.99 ', '$1.49 ', '$2.99 ', '$7.99 ',
       '$5.99 ', '$3.49 ', '$1.99 ', '$9.99 ', '$7.49 ', '$0.99 ',
       '$9.00 ', '$5.49 ', '$10.00 ', '$24.99 ', '$11.99 ', '$79.99 ',
       '$16.99 ', '$14.99 ', '$1.00 ', '$29.99 ', '$12.99 ', '$2.49 ',
       '$10.99 ', '$1.50 ', '$19.99 ', '$15.99 ', '$33.99 ', '$74.99 ',
       '$39.99 ', '$3.95 ', '$4.49 ', '$1.70 ', '$8.99 ', '$2.00 ',
       '$3.88 ', '$25.99 ', '$399.99 ', '$17.99 ', '$400.00 ', '$3.02 ',
       '$1.76 ', '$4.84 ', '$4.77 ', '$1.61 ', '$2.50 ', '$1.59 ',
       '$6.49 ', '$1.29 ', '$5.00 ', '$13.99 ', '$299.99 ', '$379.99 ',
       '$37.99 ', '$18.99 ', '$389.99 ', '$19.90 ', '$8.49 ', '$1.75 ',
       '$14.00 ', '$4.85 ', '$46.99 ', '$109.99 ', '$154.99 ', '$3.08 ',
       '$2.59 ', '$4.80 ', '$1.96 ', '$19.40 ', '$3.90 ', '$4.59 ',
       '$15.46 ', '$3.04 ', '$4.29 ', '$2.60 ', '$3.28 ', '$4.60 ',
       '$28.99 ', '$2.95 ', '$2.90 ', '$1.97 ', '$200.00 ', '$89.99 ',
       '$2.56 ', '$30.99 ', '$3.61 ', '$394.99 ', '$1.26 ', '$1.20 ',
       '$1.04 '], dtype=object)
```

```
df['Price'] = df['Price'].str.replace('$', '')
df['Price']= pd.to_numeric(df['Price'])
```

```
<ipython-input-21-0eb056e68e4e>:1: FutureWarning: The default value of regex will cha
  df['Price'] = df['Price'].str.replace('$', '')
```

```
df['Price'].unique()
```

```
array([  0.  ,   4.99,   3.99,   6.99,   1.49,   2.99,   7.99,   5.99,
         3.49,   1.99,   9.99,   7.49,   0.99,   9.  ,   5.49,  10.  ,
        24.99,  11.99,  79.99,  16.99,  14.99,   1.  ,  29.99,  12.99,
         2.49,  10.99,   1.5 ,  19.99,  15.99,  33.99,  74.99,  39.99,
         3.95,   4.49,   1.7 ,   8.99,   2.  ,   3.88,  25.99, 399.99,
        17.99, 400.  ,   3.02,   1.76,   4.84,   4.77,   1.61,   2.5 ,
         1.59,   6.49,   1.29,   5.  ,  13.99, 299.99, 379.99,  37.99,
        18.99, 389.99,  19.9 ,   8.49,   1.75,  14.  ,   4.85,  46.99,
       109.99, 154.99,   3.08,   2.59,   4.8 ,   1.96,  19.4 ,   3.9 ,
         4.59,  15.46,   3.04,   4.29,   2.6 ,   3.28,   4.6 ,  28.99,
         2.95,   2.9 ,   1.97, 200.  ,  89.99,   2.56,  30.99,   3.61,
       394.99,   1.26,   1.2 ,   1.04])
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10840 entries, 0 to 10840
Data columns (total 13 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   App             10840 non-null  object 
 1   Category        10840 non-null  object 
 2   Rating          9366 non-null   float64
 3   Reviews         10840 non-null  int64  
 4   Size            10840 non-null  object 
 5   Installs        10840 non-null  object 
 6   Type            10839 non-null  object 
 7   Price           10840 non-null  float64
 8   Content Rating  10840 non-null  object 
 9   Genres          10840 non-null  object 
```

```
  10  Last Updated    10840 non-null  object
  11  Current Ver     10832 non-null  object
  12  Android Ver     10838 non-null  object
 dtypes: float64(2), int64(1), object(10)
 memory usage: 1.2+ MB
```

```
df['Type'].isnull().sum()
```

```
1
```

```
df[df['Type'].isna() == True]
```

	App	Category	Rating	Reviews	Size	Installs	Type	Price	Content Rating
9148	Command & Conquer: Rivals	FAMILY	NaN	0	Varies with device	0	NaN	0.0	Everyone 10+

```
df['Type'].fillna('Free', inplace=True) # since price is zero we fill it up with Free
```

```
df.loc[9148]
```

```
App               Command & Conquer: Rivals
Category                             FAMILY
Rating                                  NaN
Reviews                                   0
Size                     Varies with device
Installs                                  0
Type                                   Free
Price                                   0.0
Content Rating                 Everyone 10+
Genres                             Strategy
Last Updated                      28-Jun-18
Current Ver              Varies with device
Android Ver              Varies with device
Name: 9148, dtype: object
```

```
df[df['Android Ver'].isna() == True]
```

```
df['Genres'].unique()
```

```
array(['Art & Design', 'Art & Design;Pretend Play',
       'Art & Design;Creativity', 'Art & Design;Action & Adventure',
       'Auto & Vehicles', 'Beauty', 'Books & Reference', 'Business',
       'Comics', 'Comics;Creativity', 'Communication', 'Dating',
       'Education;Education', 'Education', 'Education;Creativity',
       'Education;Music & Video', 'Education;Action & Adventure',
       'Education;Pretend Play', 'Education;Brain Games', 'Entertainment',
       'Entertainment;Music & Video', 'Entertainment;Brain Games',
       'Entertainment;Creativity', 'Events', 'Finance', 'Food & Drink',
       'Health & Fitness', 'House & Home', 'Libraries & Demo',
       'Lifestyle', 'Lifestyle;Pretend Play',
       'Adventure;Action & Adventure', 'Arcade', 'Casual', 'Card',
       'Casual;Pretend Play', 'Action', 'Strategy', 'Puzzle', 'Sports',
       'Music', 'Word', 'Racing', 'Casual;Creativity',
       'Casual;Action & Adventure', 'Simulation', 'Adventure', 'Board',
       'Trivia', 'Role Playing', 'Simulation;Education',
       'Action;Action & Adventure', 'Casual;Brain Games',
       'Simulation;Action & Adventure', 'Educational;Creativity',
       'Puzzle;Brain Games', 'Educational;Education', 'Card;Brain Games',
       'Educational;Brain Games', 'Educational;Pretend Play',
       'Entertainment;Education', 'Casual;Education',
       'Music;Music & Video', 'Racing;Action & Adventure',
       'Arcade;Pretend Play', 'Role Playing;Action & Adventure',
       'Simulation;Pretend Play', 'Puzzle;Creativity',
       'Sports;Action & Adventure', 'Educational;Action & Adventure',
       'Arcade;Action & Adventure', 'Entertainment;Action & Adventure',
       'Puzzle;Action & Adventure', 'Strategy;Action & Adventure',
       'Music & Audio;Music & Video', 'Health & Fitness;Education',
       'Adventure;Education', 'Board;Brain Games',
       'Board;Action & Adventure', 'Board;Pretend Play',
       'Casual;Music & Video', 'Role Playing;Pretend Play',
       'Entertainment;Pretend Play', 'Video Players & Editors;Creativity',
       'Card;Action & Adventure', 'Medical', 'Social', 'Shopping',
       'Photography', 'Travel & Local',
       'Travel & Local;Action & Adventure', 'Tools', 'Tools;Education',
       'Personalization', 'Productivity', 'Parenting',
       'Parenting;Music & Video', 'Parenting;Education',
       'Parenting;Brain Games', 'Weather', 'Video Players & Editors',
       'Video Players & Editors;Music & Video', 'News & Magazines',
       'Maps & Navigation', 'Health & Fitness;Action & Adventure',
       'Educational', 'Casino', 'Adventure;Brain Games',
       'Trivia;Education', 'Lifestyle;Education',
       'Books & Reference;Creativity', 'Books & Reference;Education',
       'Puzzle;Education', 'Role Playing;Education',
       'Role Playing;Brain Games', 'Strategy;Education',
       'Racing;Pretend Play', 'Communication;Creativity',
       'Strategy;Creativity'], dtype=object)
```

```
df['Category'].unique()
```

```
array(['ART_AND_DESIGN', 'AUTO_AND_VEHICLES', 'BEAUTY',
       'BOOKS_AND_REFERENCE', 'BUSINESS', 'COMICS', 'COMMUNICATION',
       'DATING', 'EDUCATION', 'ENTERTAINMENT', 'EVENTS', 'FINANCE',
       'FOOD_AND_DRINK', 'HEALTH_AND_FITNESS', 'HOUSE_AND_HOME',
       'LIBRARIES_AND_DEMO', 'LIFESTYLE', 'GAME', 'FAMILY', 'MEDICAL',
       'SOCIAL', 'SHOPPING', 'PHOTOGRAPHY', 'SPORTS', 'TRAVEL_AND_LOCAL',
       'TOOLS', 'PERSONALIZATION', 'PRODUCTIVITY', 'PARENTING', 'WEATHER',
       'VIDEO_PLAYERS', 'NEWS_AND_MAGAZINES', 'MAPS_AND_NAVIGATION'],
      dtype=object)
```

```
#genres and category might have corelation
```

```
df['Last Updated'] = pd.to_datetime(df['Last Updated'], format = '%d-%b-%y') # treating th
df['Last Updated']
```

```
0       2018-01-07
1       2018-01-15
2       2018-08-01
3       2018-06-08
4       2018-06-20
           ...
10836   2017-07-25
10837   2018-07-06
10838   2017-01-20
10839   2015-01-19
10840   2018-07-25
Name: Last Updated, Length: 10840, dtype: datetime64[ns]
```

```
df['Last Updated'].max()
```

```
Timestamp('2018-08-08 00:00:00')
```

```
pd.to_datetime('2018-12-31') - df['Last Updated']
df['Last Updated'] = round(pd.to_numeric((pd.to_datetime('2018-12-31') - df['Last Updated'
df['Last Updated']
```

```
0        12.0
1        11.0
2         5.0
3         7.0
4         6.0
         ...
10836    17.0
10837     6.0
10838    23.0
10839    47.0
10840     5.0
Name: Last Updated, Length: 10840, dtype: float64
```

```
df['Last Updated'].describe()
```

```
count    10840.000000
mean        13.283210
std         12.974659
min          5.000000
25%          5.000000
50%          7.000000
75%         15.000000
max        103.000000
Name: Last Updated, dtype: float64
```

```
# we drop the Type feature as free apps will have price = 0 and paid apps will have some p
df = df.drop(['Type'], axis = 1)
df.head()
```

	App	Category	Rating	Reviews	Size	Installs	Price	Content Rating
0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19M	10,000+	0.0	Everyone
1	Coloring book moana	ART_AND_DESIGN	3.9	967	14M	500,000+	0.0	Everyone
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8.7M	5,000,000+	0.0	Everyone

```
df.isnull().sum()
```

```
App                  0
Category             0
Rating            1474
Reviews              0
Size                 0
Installs             0
Price                0
Content Rating       0
Genres               0
Last Updated         0
Current Ver          8
Android Ver          2
dtype: int64
```

```
df['App'].value_counts()
```

```
ROBLOX                                                 9
CBS Sports App - Scores, News, Stats & Watch Live      8
ESPN                                                   7
Duolingo: Learn Languages Free                         7
Candy Crush Saga                                       7
                                                      ..
Meet U - Get Friends for Snapchat, Kik & Instagram     1
U-Report                                               1
U of I Community Credit Union                          1
Waiting For U Launcher Theme                           1
iHoroscope - 2018 Daily Horoscope & Astrology          1
Name: App, Length: 9659, dtype: int64
```

```
df[df['App'] == 'ROBLOX']
```

	App	Category	Rating	Reviews	Size	Installs	Price	Content Rating	
1653	ROBLOX	GAME	4.5	4447388	67M	100,000,000+	0.0	Everyone 10+	Adventu & A
1701	ROBLOX	GAME	4.5	4447346	67M	100,000,000+	0.0	Everyone 10+	Adventu & A
1748	ROBLOX	GAME	4.5	4448791	67M	100,000,000+	0.0	Everyone 10+	Adventu & A
1841	ROBLOX	GAME	4.5	4449882	67M	100,000,000+	0.0	Everyone 10+	Adventu & A
1870	ROBLOX	GAME	4.5	4449910	67M	100,000,000+	0.0	Everyone 10+	Adventu & A
2016	ROBLOX	FAMILY	4.5	4449910	67M	100,000,000+	0.0	Everyone 10+	Adventu & A
2088	ROBLOX	FAMILY	4.5	4450855	67M	100,000,000+	0.0	Everyone	Adventu

```
df = df.drop_duplicates(subset=['App']) # dropping duplicates
```

```
df.shape
```

```
(9659, 12)
```

```
df['App'].value_counts()
```

```
Photo Editor & Candy Camera & Grid & ScrapBook    1
Tic Tac CK                                        1
INFAMY RO                                         1
CK Call NEW                                       1
Ck Coif                                           1
                                                 ..
Bike Race Free - Top Motorcycle Racing Games      1
Dance School Stories - Dance Dreams Come True     1
3D Bowling                                        1
Mind Games Pro                                    1
iHoroscope - 2018 Daily Horoscope & Astrology     1
Name: App, Length: 9659, dtype: int64
```

```
df['Size'].unique()
```

```
array(['19M', '14M', '8.7M', '25M', '2.8M', '5.6M', '29M', '33M', '3.1M',
       '28M', '12M', '20M', '21M', '37M', '2.7M', '5.5M', '17M', '39M',
       '31M', '4.2M', '7.0M', '23M', '6.0M', '6.1M', '4.6M', '9.2M',
       '5.2M', '11M', '24M', 'Varies with device', '9.4M', '15M', '10M',
       '1.2M', '26M', '8.0M', '7.9M', '56M', '57M', '35M', '54M', '201k',
       '3.6M', '5.7M', '8.6M', '2.4M', '27M', '2.5M', '16M', '3.4M',
       '8.9M', '3.9M', '2.9M', '38M', '32M', '5.4M', '18M', '1.1M',
       '2.2M', '4.5M', '9.8M', '52M', '9.0M', '6.7M', '30M', '2.6M',
       '7.1M', '3.7M', '22M', '7.4M', '6.4M', '3.2M', '8.2M', '9.9M',
       '4.9M', '9.5M', '5.0M', '5.9M', '13M', '73M', '6.8M', '3.5M',
       '4.0M', '2.3M', '7.2M', '2.1M', '42M', '7.3M', '9.1M', '55M',
       '23k', '6.5M', '1.5M', '7.5M', '51M', '41M', '48M', '8.5M', '46M',
       '8.3M', '4.3M', '4.7M', '3.3M', '40M', '7.8M', '8.8M', '6.6M',
       '5.1M', '61M', '66M', '79k', '8.4M', '118k', '44M', '695k', '1.6M',
       '6.2M', '18k', '53M', '1.4M', '3.0M', '5.8M', '3.8M', '9.6M',
       '45M', '63M', '49M', '77M', '4.4M', '4.8M', '70M', '6.9M', '9.3M',
       '10.0M', '8.1M', '36M', '84M', '97M', '2.0M', '1.9M', '1.8M',
       '5.3M', '47M', '556k', '526k', '76M', '7.6M', '59M', '9.7M', '78M',
       '72M', '43M', '7.7M', '6.3M', '334k', '34M', '93M', '65M', '79M',
       '100M', '58M', '50M', '68M', '64M', '67M', '60M', '94M', '232k',
       '99M', '624k', '95M', '8.5k', '41k', '292k', '11k', '80M', '1.7M',
       '74M', '62M', '69M', '75M', '98M', '85M', '82M', '96M', '87M',
       '71M', '86M', '91M', '81M', '92M', '83M', '88M', '704k', '862k',
       '899k', '378k', '266k', '375k', '1.3M', '975k', '980k', '4.1M',
       '89M', '696k', '544k', '525k', '920k', '779k', '853k', '720k',
       '713k', '772k', '318k', '58k', '241k', '196k', '857k', '51k',
       '953k', '865k', '251k', '930k', '540k', '313k', '746k', '203k',
       '26k', '314k', '239k', '371k', '220k', '730k', '756k', '91k',
       '293k', '17k', '74k', '14k', '317k', '78k', '924k', '902k', '818k',
       '81k', '939k', '169k', '45k', '475k', '965k', '90M', '545k', '61k',
       '283k', '655k', '714k', '93k', '872k', '121k', '322k', '1.0M',
       '976k', '172k', '238k', '549k', '206k', '954k', '444k', '717k',
       '210k', '609k', '308k', '705k', '306k', '904k', '473k', '175k',
       '350k', '383k', '454k', '421k', '70k', '812k', '442k', '842k',
       '417k', '412k', '459k', '478k', '335k', '782k', '721k', '430k',
       '429k', '192k', '200k', '460k', '728k', '496k', '816k', '414k',
       '506k', '887k', '613k', '243k', '569k', '778k', '683k', '592k',
       '319k', '186k', '840k', '647k', '191k', '373k', '437k', '598k',
       '716k', '585k', '982k', '222k', '219k', '55k', '948k', '323k',
       '691k', '511k', '951k', '963k', '25k', '554k', '351k', '27k',
       '82k', '208k', '913k', '514k', '551k', '29k', '103k', '898k',
       '743k', '116k', '153k', '209k', '353k', '499k', '173k', '597k',
       '809k', '122k', '411k', '400k', '801k', '787k', '237k', '50k',
       '643k', '986k', '97k', '516k', '837k', '780k', '961k', '269k',
       '20k', '498k', '600k', '749k', '642k', '881k', '72k', '656k',
       '601k', '221k', '228k', '108k', '940k', '176k', '33k', '663k',
       '34k', '942k', '259k', '164k', '458k', '245k', '629k', '28k',
       '288k', '775k', '785k', '636k', '916k', '994k', '309k', '485k',
       '914k', '903k', '608k', '500k', '54k', '562k', '847k', '957k',
       '688k', '811k', '270k', '48k', '329k', '523k', '921k', '874k',
       '981k', '784k', '280k', '24k', '518k', '754k', '892k', '154k',
       '860k', '364k', '387k', '626k', '161k', '879k', '39k', '970k',
       '170k', '141k', '160k', '144k', '143k', '190k', '376k', '193k',
       '246k', '73k', '658k', '992k', '253k', '420k', '404k', '470k',
       '226k', '240k', '89k', '234k', '257k', '861k', '467k', '157k',
       '44k', '676k', '67k', '552k', '885k', '1020k', '582k', '619k'],
      dtype=object)
```

```
df['Size'].value_counts()
```

```
Varies with device    1227
11M                    182
12M                    181
14M                    177
13M                    177
                      ...
430k                     1
```

```
429k                    1
200k                    1
460k                    1
619k                    1
Name: Size, Length: 461, dtype: int64
```

```
df.head()
```

	App	Category	Rating	Reviews	Size	Installs	Price	Content Rating
0	Photo Editor & Candy Camera & Grid & ScrapBook	ART_AND_DESIGN	4.1	159	19M	10,000+	0.0	Everyone
1	Coloring book moana	ART_AND_DESIGN	3.9	967	14M	500,000+	0.0	Everyone
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	ART_AND_DESIGN	4.7	87510	8.7M	5,000,000+	0.0	Everyone

```
df['Content Rating'].value_counts()
```

```
Everyone           7903
Teen               1036
Mature 17+          393
Everyone 10+        322
Adults only 18+       3
Unrated               2
Name: Content Rating, dtype: int64
```

```
from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()
df['Content Rating'] = encoder.fit_transform(df['Content Rating'])
df['Category'] = encoder.fit_transform(df['Category'])
```

```
df['Content Rating'].value_counts()
```

```
1    7903
4    1036
3     393
2     322
0       3
5       2
Name: Content Rating, dtype: int64
```

```
df['Installs'].unique()
```

```
array(['10,000+', '500,000+', '5,000,000+', '50,000,000+', '100,000+',
       '50,000+', '1,000,000+', '10,000,000+', '5,000+', '100,000,000+',
       '1,000,000,000+', '1,000+', '500,000,000+', '50+', '100+', '500+',
       '10+', '1+', '5+', '0+', '0'], dtype=object)
```

```
df['Installs'] = df['Installs'].str.replace('+', '')
df['Installs'] = df['Installs'].str.replace(',', '')
```

```
<ipython-input-50-a8afa419ebdf>:1: FutureWarning: The default value of regex will cha
  df['Installs'] = df['Installs'].str.replace('+', '')
```

```
df['Installs']= pd.to_numeric(df['Installs'])
```

```
df['Installs'].unique()
```

```
array([     10000,     500000,    5000000,   50000000,     100000,
            50000,    1000000,   10000000,       5000,  100000000,
       1000000000,       1000,  500000000,         50,        100,
              500,         10,          1,          5,          0])
```

```
df['Installs'].info()
```

```
<class 'pandas.core.series.Series'>
Int64Index: 9659 entries, 0 to 10840
Series name: Installs
Non-Null Count  Dtype
--------------  -----
9659 non-null   int64
dtypes: int64(1)
memory usage: 150.9 KB
```

```
df.sample(3)
```

	App	Category	Rating	Reviews	Size	Installs	Price	Content Rating	
3103	trivago: Hotels & Travel	30	4.2	219848	Varies with device	50000000	0.0	1	T
8757	Dr. Driving 2	14	4.6	358633	19M	10000000	0.0	1	
9632	Keyboard ManMan	29	4.4	121304	Varies with device	10000000	0.0	1	

```
df.isnull().sum()
```

```
App                  0
Category             0
Rating            1463
Reviews              0
Size                 0
Installs             0
Price                0
Content Rating       0
Genres               0
Last Updated         0
Current Ver          8
Android Ver          2
dtype: int64
```

```
df = df.drop(['Current Ver', 'Genres' ], axis = 1,)
df
```

	App	Category	Rating	Reviews	Size	Installs	Pri
0	Photo Editor & Candy Camera & Grid & ScrapBook	0	4.1	159	19M	10000	(
1	Coloring book moana	0	3.9	967	14M	500000	(
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	0	4.7	87510	8.7M	5000000	(
3	Sketch - Draw & Paint	0	4.5	215644	25M	50000000	(
4	Pixel Draw - Number Art Coloring Book	0	4.3	967	2.8M	100000	(
...	...	...	...	...	...	...	
10836	Sya9a Maroc - FR	11	4.5	38	53M	5000	(
10837	Fr. Mike Schmitz Audio Teachings	11	5.0	4	3.6M	100	(
10838	Parkinson Exercices FR	20	NaN	3	9.5M	1000	(
10839	The SCP Foundation DB fr nn5n	3	4.5	114	Varies with device	1000	(
10840	iHoroscope - 2018 Daily Horoscope & Astrology	18	4.5	398307	19M	10000000	(

9659 rows × 10 columns

```
df.sample(3)
```

```
df["Size"].unique()
```

```
array(['19M', '14M', '8.7M', '25M', '2.8M', '5.6M', '29M', '33M', '3.1M',
       '28M', '12M', '20M', '21M', '37M', '2.7M', '5.5M', '17M', '39M',
       '31M', '4.2M', '7.0M', '23M', '6.0M', '6.1M', '4.6M', '9.2M',
       '5.2M', '11M', '24M', 'Varies with device', '9.4M', '15M', '10M',
       '1.2M', '26M', '8.0M', '7.9M', '56M', '57M', '35M', '54M', '201k',
       '3.6M', '5.7M', '8.6M', '2.4M', '27M', '2.5M', '16M', '3.4M',
       '8.9M', '3.9M', '2.9M', '38M', '32M', '5.4M', '18M', '1.1M',
       '2.2M', '4.5M', '9.8M', '52M', '9.0M', '6.7M', '30M', '2.6M',
       '7.1M', '3.7M', '22M', '7.4M', '6.4M', '3.2M', '8.2M', '9.9M',
       '4.9M', '9.5M', '5.0M', '5.9M', '13M', '73M', '6.8M', '3.5M',
       '4.0M', '2.3M', '7.2M', '2.1M', '42M', '7.3M', '9.1M', '55M',
       '23k', '6.5M', '1.5M', '7.5M', '51M', '41M', '48M', '8.5M', '46M',
       '8.3M', '4.3M', '4.7M', '3.3M', '40M', '7.8M', '8.8M', '6.6M',
       '5.1M', '61M', '66M', '79k', '8.4M', '118k', '44M', '695k', '1.6M',
       '6.2M', '18k', '53M', '1.4M', '3.0M', '5.8M', '3.8M', '9.6M',
       '45M', '63M', '49M', '77M', '4.4M', '4.8M', '70M', '6.9M', '9.3M',
       '10.0M', '8.1M', '36M', '84M', '97M', '2.0M', '1.9M', '1.8M',
       '5.3M', '47M', '556k', '526k', '76M', '7.6M', '59M', '9.7M', '78M',
       '72M', '43M', '7.7M', '6.3M', '334k', '34M', '93M', '65M', '79M',
       '100M', '58M', '50M', '68M', '64M', '67M', '60M', '94M', '232k',
       '99M', '624k', '95M', '8.5k', '41k', '292k', '11k', '80M', '1.7M',
       '74M', '62M', '69M', '75M', '98M', '85M', '82M', '96M', '87M',
       '71M', '86M', '91M', '81M', '92M', '83M', '88M', '704k', '862k',
       '899k', '378k', '266k', '375k', '1.3M', '975k', '980k', '4.1M',
       '89M', '696k', '544k', '525k', '920k', '779k', '853k', '720k',
       '713k', '772k', '318k', '58k', '241k', '196k', '857k', '51k',
       '953k', '865k', '251k', '930k', '540k', '313k', '746k', '203k',
       '26k', '314k', '239k', '371k', '220k', '730k', '756k', '91k',
       '293k', '17k', '74k', '14k', '317k', '78k', '924k', '902k', '818k',
       '81k', '939k', '169k', '45k', '475k', '965k', '90M', '545k', '61k',
       '283k', '655k', '714k', '93k', '872k', '121k', '322k', '1.0M',
       '976k', '172k', '238k', '549k', '206k', '954k', '444k', '717k',
       '210k', '609k', '308k', '705k', '306k', '904k', '473k', '175k',
       '350k', '383k', '454k', '421k', '70k', '812k', '442k', '842k',
       '417k', '412k', '459k', '478k', '335k', '782k', '721k', '430k',
       '429k', '192k', '200k', '460k', '728k', '496k', '816k', '414k',
       '506k', '887k', '613k', '243k', '569k', '778k', '683k', '592k',
       '319k', '186k', '840k', '647k', '191k', '373k', '437k', '598k',
       '716k', '585k', '982k', '222k', '219k', '55k', '948k', '323k',
       '691k', '511k', '951k', '963k', '25k', '554k', '351k', '27k',
       '82k', '208k', '913k', '514k', '551k', '29k', '103k', '898k',
       '743k', '116k', '153k', '209k', '353k', '499k', '173k', '597k',
       '809k', '122k', '411k', '400k', '801k', '787k', '237k', '50k',
       '643k', '986k', '97k', '516k', '837k', '780k', '961k', '269k',
       '20k', '498k', '600k', '749k', '642k', '881k', '72k', '656k',
       '601k', '221k', '228k', '108k', '940k', '176k', '33k', '663k',
       '34k', '942k', '259k', '164k', '458k', '245k', '629k', '28k',
       '288k', '775k', '785k', '636k', '916k', '994k', '309k', '485k',
       '914k', '903k', '608k', '500k', '54k', '562k', '847k', '957k',
       '688k', '811k', '270k', '48k', '329k', '523k', '921k', '874k',
       '981k', '784k', '280k', '24k', '518k', '754k', '892k', '154k',
       '860k', '364k', '387k', '626k', '161k', '879k', '39k', '970k',
       '170k', '141k', '160k', '144k', '143k', '190k', '376k', '193k',
       '246k', '73k', '658k', '992k', '253k', '420k', '404k', '470k',
       '226k', '240k', '89k', '234k', '257k', '861k', '467k', '157k',
       '44k', '676k', '67k', '552k', '885k', '1020k', '582k', '619k'],
      dtype=object)
```

```
def size_to_num(size_str):
    if size_str == 'Varies with device':
        return None
    size_num = float(re.findall(r'\d+\.\d+|\d+', size_str)[0])
    if 'M' in size_str:
        size_num *= 1024
    return size_num

df['Size'] = df['Size'].apply(size_to_num).astype(float)
df.dropna(inplace=True)
```

```
df['Android Ver'].unique()
```

```
     array(['4.0.3 and up', '4.2 and up', '4.4 and up', '2.3 and up',
            '3.0 and up', '4.1 and up', '4.0 and up', '2.2 and up',
            '5.0 and up', '6.0 and up', '1.6 and up', '2.1 and up',
            '1.5 and up', '7.0 and up', '4.3 and up', '4.0.3 - 7.1.1',
            '2.0 and up', '2.3.3 and up', 'Varies with device', '3.2 and up',
            '4.4W and up', '5.1 and up', '7.1 and up', '7.0 - 7.1.1',
            '8.0 and up', '5.0 - 8.0', '3.1 and up', '2.0.1 and up',
            '4.1 - 7.1.1', '5.0 - 6.0', '1.0 and up'], dtype=object)
```

```
df['Android Ver'].replace(to_replace=['4.4W and up','Varies with device'], value=['4.4',np
df['Android Ver'].replace({k: '1.0' for k in ['1.0','1.0 and up','1.5 and up','1.6 and up'
df['Android Ver'].replace({k: '2.0' for k in ['2.0 and up','2.0.1 and up','2.1 and up','2.
df['Android Ver'].replace({k: '3.0' for k in ['3.0 and up','3.1 and up','3.2 and up']},inp
df['Android Ver'].replace({k: '4.0' for k in ['4.0 and up','4.0.3 and up','4.0.3 - 7.1.1',
df['Android Ver'].replace({k: '5.0' for k in ['5.0 - 6.0','5.0 - 7.1.1','5.0 - 8.0','5.0 a
df['Android Ver'].replace({k: '6.0' for k in ['6.0 and up']},inplace=True)
df['Android Ver'].replace({k: '7.0' for k in ['7.0 - 7.1.1','7.0 and up','7.1 and up']},in
df['Android Ver'].replace({k: '8.0' for k in ['8.0 and up']},inplace=True)
df['Android Ver'].fillna('1.0', inplace=True)
```

```
df.head()
```

	App	Category	Rating	Reviews	Size	Installs	Pric
0	Photo Editor & Candy Camera & Grid & ScrapBook	0	4.1	159	19456.0	10000	0.
1	Coloring book moana	0	3.9	967	14336.0	500000	0.
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	0	4.7	87510	8908.8	5000000	0.
3	Sketch - Draw & Paint	0	4.5	215644	25600.0	50000000	0.

```
df['Android Ver'].unique()
```

```
    array(['4.0', '2.0', '3.0', '5.0', '6.0', '1.0', '7.0', '8.0'],
          dtype=object)
```

```
df['Android Ver']= pd.to_numeric(df['Android Ver'])
```

```
df.head(3)
```

	App	Category	Rating	Reviews	Size	Installs	Pric
0	Photo Editor & Candy Camera & Grid & ScrapBook	0	4.1	159	19456.0	10000	0.
1	Coloring book moana	0	3.9	967	14336.0	500000	0.

```
df['Reviews_per_thousands'] = df['Reviews']/1000
df['Downloads_per_thousands'] = df['Installs']/1000
df = df.drop(['Reviews', 'Installs'], axis = 1)
```

```
df.isnull().sum()
```

```
    App                        0
    Category                   0
    Rating                     0
    Size                       0
    Price                      0
    Content Rating             0
    Last Updated               0
    Android Ver                0
    Reviews_per_thousands      0
    Downloads_per_thousands    0
    dtype: int64
```

```
df.describe()
```

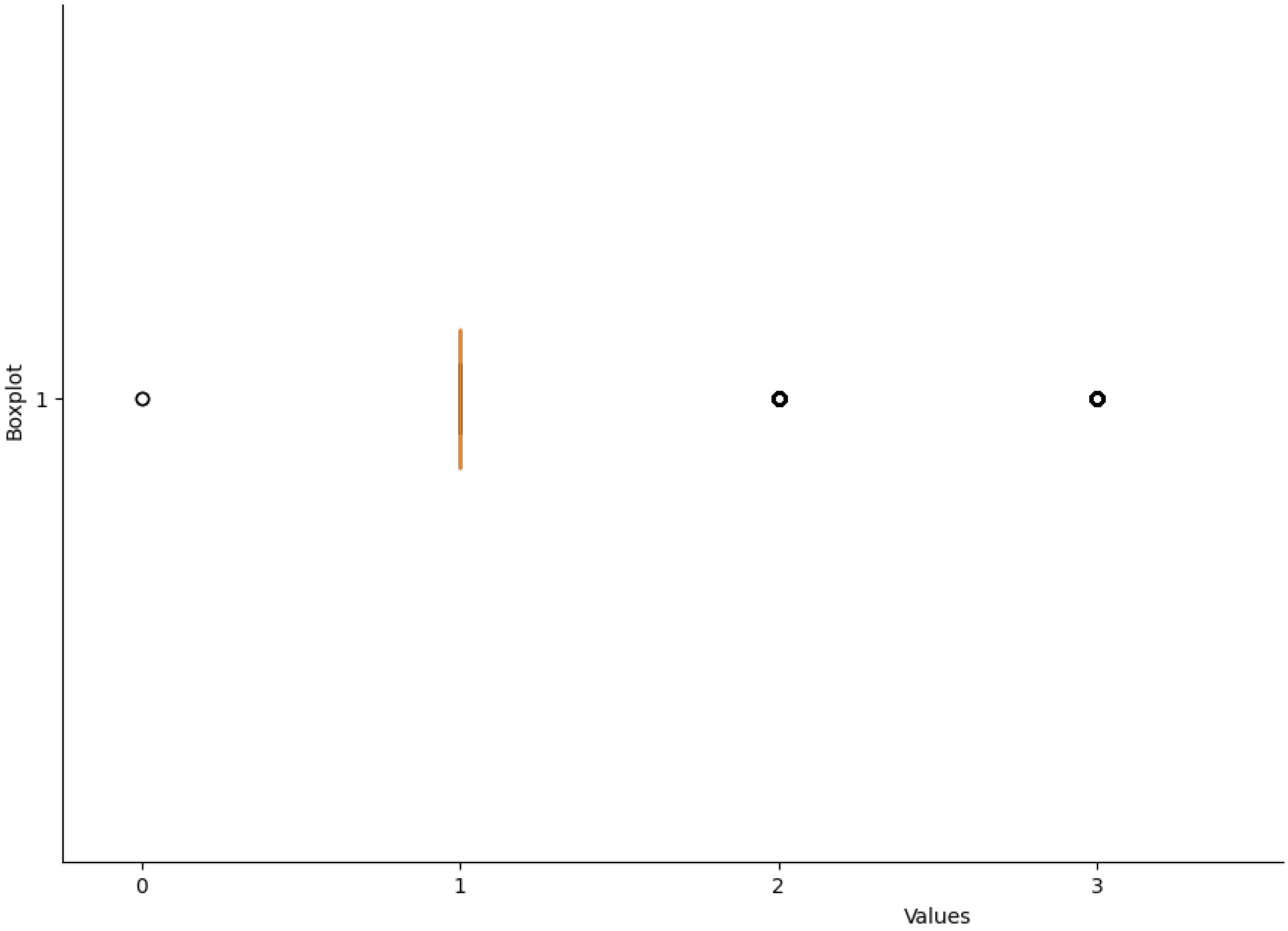
	Category	Rating	Size	Price	Content Rating	Last Updated
count	7025.000000	7025.000000	7025.000000	7025.000000	7025.000000	7025.000000
mean	16.642562	4.160541	22280.590078	1.173694	1.456370	14.637438
std	8.205916	0.559203	23273.991643	18.200187	1.001201	14.016990
min	0.000000	1.000000	8.500000	0.000000	0.000000	5.000000
25%	11.000000	4.000000	5017.600000	0.000000	1.000000	6.000000
50%	14.000000	4.300000	13312.000000	0.000000	1.000000	8.000000
75%	24.000000	4.500000	31744.000000	0.000000	1.000000	18.000000
max	32.000000	5.000000	102400.000000	400.000000	5.000000	103.000000

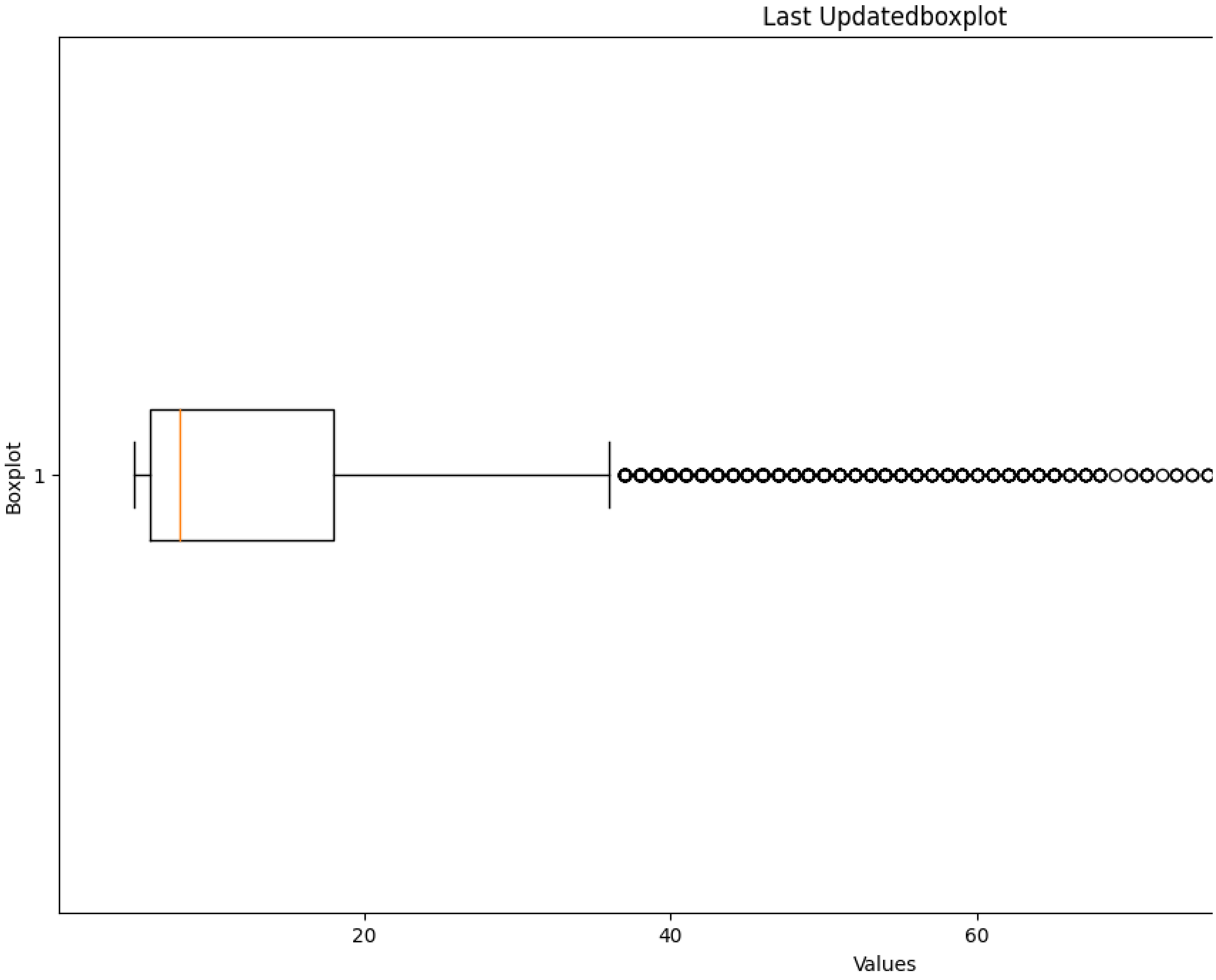
```
k = df.drop(['App'], axis = 1)
k
```

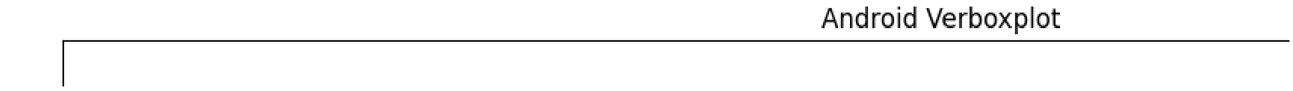
	Category	Rating	Size	Price	Content Rating	Last Updated	Android Ver	Reviews_
0	0	4.1	19456.0	0.0	1	12.0	4.0	
1	0	3.9	14336.0	0.0	1	11.0	4.0	
2	0	4.7	8908.8	0.0	1	5.0	4.0	
3	0	4.5	25600.0	0.0	4	7.0	4.0	
4	0	4.3	2867.2	0.0	1	6.0	4.0	
...	...	...	...	...	...	...	...	
10833	3	4.8	619.0	0.0	1	57.0	2.0	
10834	11	4.0	2662.4	0.0	1	18.0	4.0	
10836	11	4.5	54272.0	0.0	1	17.0	4.0	
10837	11	5.0	3686.4	0.0	1	6.0	4.0	
10840	18	4.5	19456.0	0.0	1	5.0	1.0	

7025 rows × 9 columns

```
for col in k.columns:
    f, ax1 = plt.subplots(figsize = (15,8))
    plt.boxplot(k[col], vert = False)
    plt.title(col  +  'boxplot')
    plt.xlabel('Values')
    plt.ylabel('Boxplot')
```

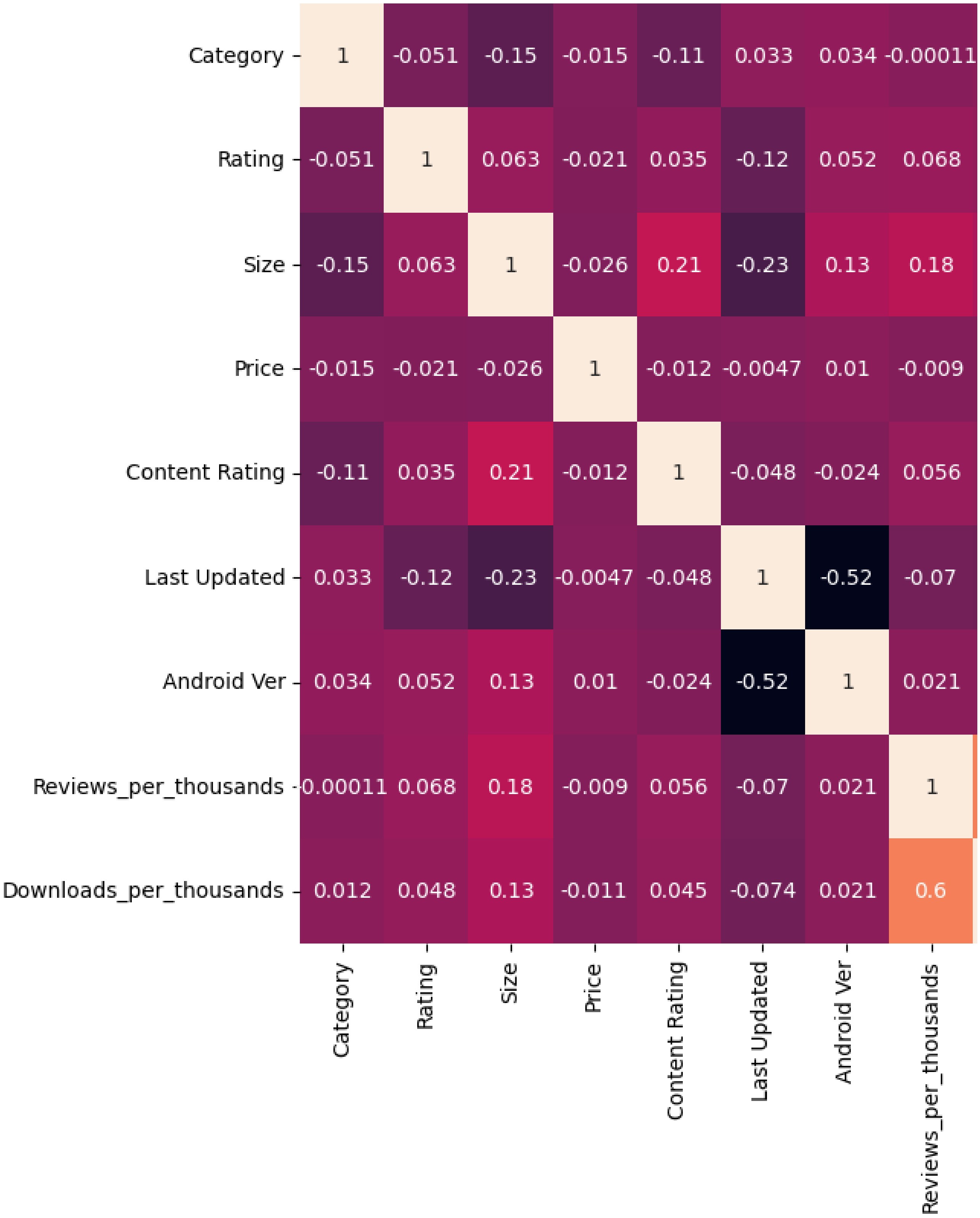

Boxplot
1
0
1
2
3
Values


Last Updatedboxplot
Boxplot
1
20
40
60
Values


Android Verboxplot

```
corr = k.corr()
f, ax = plt.subplots(figsize = (8,8))
sns.heatmap(corr, annot = True)
```

```
<Axes: >
```



```
#Reviews and  downloads high a very high corelation, which indicates that the greater the
#last updated and android version is having high corelation
```

```
# Multicollinearity test
##- Variance Inflation factor (VIF) (stage 2)
###- If vif > 5, multicollinearity exist.
```

```
vif = pd.DataFrame()
features = k.drop(['Downloads_per_thousands'] , axis= 1)
vif['features_name'] = features.columns
vif['vif'] = [variance_inflation_factor(features.values,i) for i in range(features.shape[1
```

```
vif
```

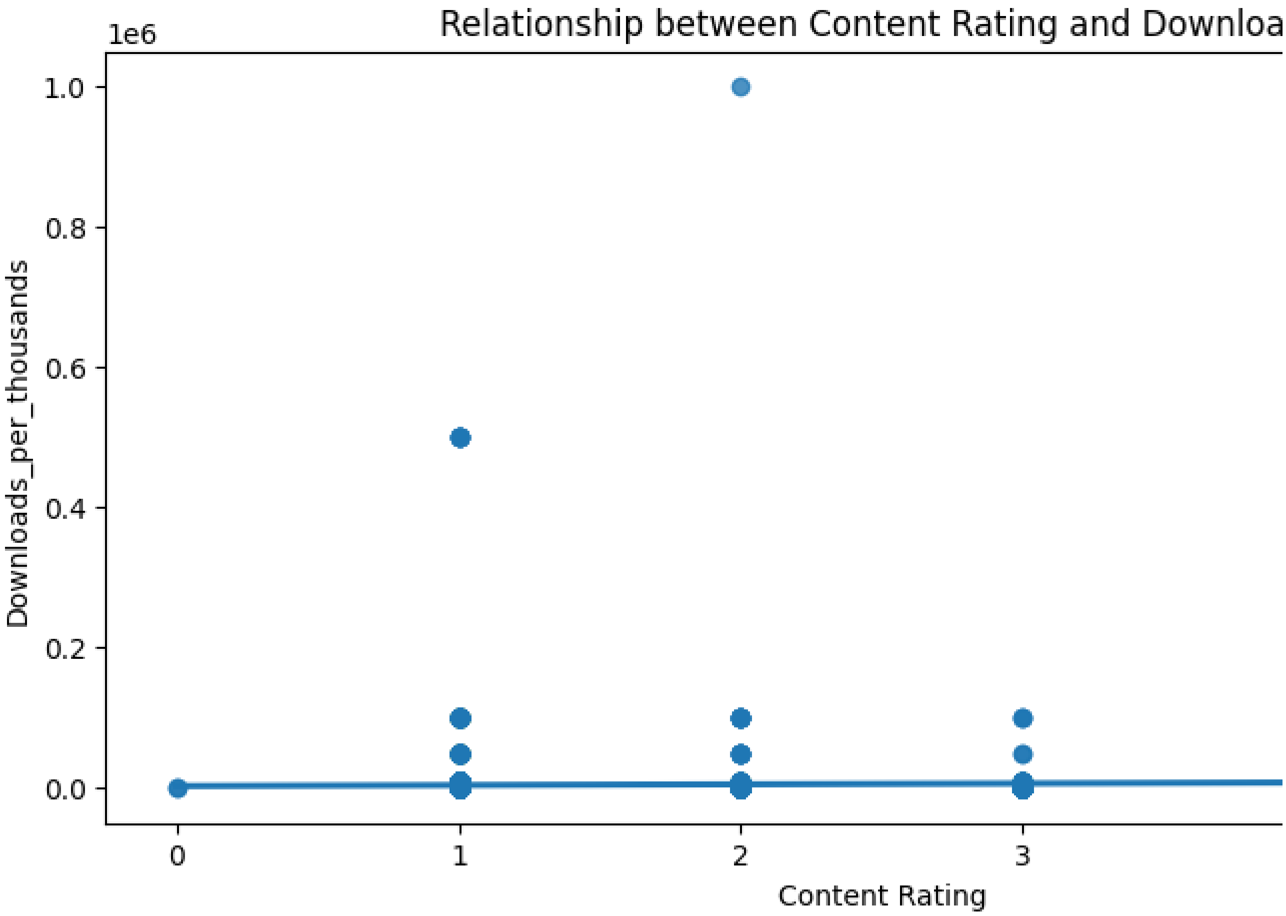
	features_name	vif
0	Category	5.002470
1	Rating	21.835413
2	Size	2.193034
3	Price	1.005203
4	Content Rating	3.205607
5	Last Updated	2.380264
6	Android Ver	15.875578
7	Reviews_per_thousands	1.058534

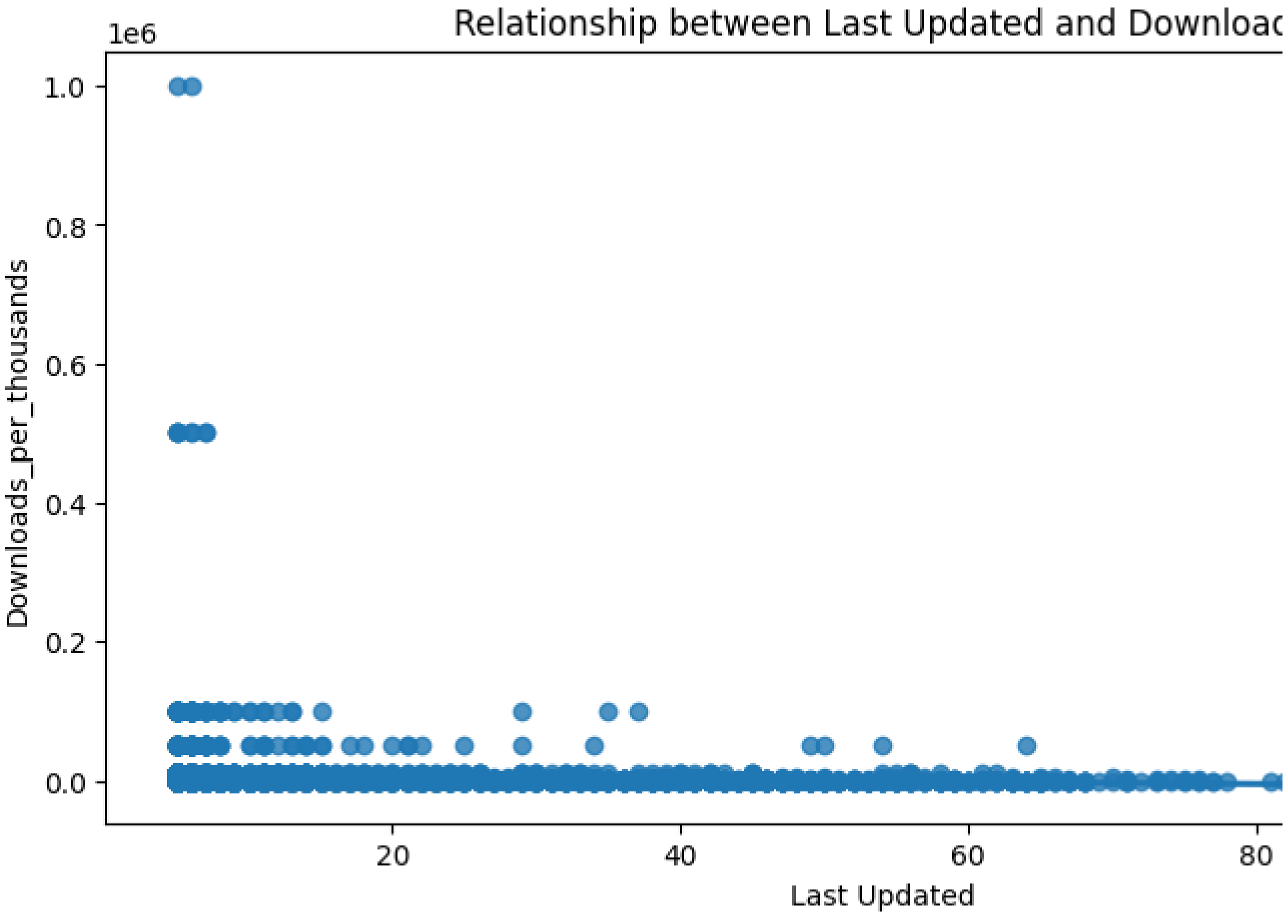
```
###  Rating and Android Verion have VIF more than 5 so mukticolinearity doesnt exist. We r
```

```
k = k.drop(['Rating'], axis = 1)
```

```
for col in k.columns:
    if col != 'Downloads_per_thousands':
        fig , ax1 = plt.subplots(figsize = (10 , 5))
        sns.regplot(x=k[col],y=k['Downloads_per_thousands'],ax = ax1).set_title(f'Relation
```

Price


Relationship between Content Rating and Downloa
1e6
1.0
0.8
0.6
0.4
0.2
0.0
Downloads_per_thousands
0
1
2
3
Content Rating


Relationship between Last Updated and Downloac
1e6
1.0
0.8
0.6
0.4
0.2
0.0
Downloads_per_thousands
20
40
60
80
Last Updated

Relationship between Android Ver and Download:
1e6
1.0

Applying log transormation on Downloads & Reviews

```
k['Downloads_per_thousands_log'] = np.log1p(k['Downloads_per_thousands'])
```

```
k['Downloads_per_thousands_log'].unique()
```

```
array([2.39789527e+00, 6.21660610e+00, 8.51739317e+00, 1.08197983e+01,
       4.61512052e+00, 3.93182563e+00, 6.90875478e+00, 9.21044037e+00,
       1.79175947e+00, 1.15129355e+01, 6.93147181e-01, 1.31223654e+01,
       9.53101798e-02, 4.05465108e-01, 9.95033085e-03, 1.38155116e+01,
       4.98754151e-03, 4.87901642e-02, 9.99500333e-04])
```

```
k['Reviews_per_thousands_log'] = np.log1p(k['Reviews_per_thousands'])
```

```
k.Reviews_per_thousands_log.unique()
```

```
array([0.14755756, 0.67650954, 4.48311554, ..., 0.47187687, 0.78618205,
       5.98973054])
```

```
k.head(2)
```

	Category	Size	Price	Content Rating	Last Updated	Android Ver	Reviews_per_thousands	Downlo
0	0	19456.0	0.0	1	12.0	4.0	0.159	
1	0	14336.0	0.0	1	11.0	4.0	0.967	

```
k = k.drop(['Reviews_per_thousands','Downloads_per_thousands'], axis = 1)
k.head(2)
```

	Category	Size	Price	Content Rating	Last Updated	Android Ver	Downloads_per_th
0	0	19456.0	0.0	1	12.0	4.0	
1	0	14336.0	0.0	1	11.0	4.0	

```
scaler = MinMaxScaler()
k['Size_scaled'] = scaler.fit_transform(df[['Size']])
```

```
k = k.drop(['Size'], axis = 1)
k.head(3)
```

Category	Price	Content Rating	Last Updated	Android Ver	Downloads_per_thousands_log

Model Building

Stages of Model Building:

1)Custom Train Test Split Function

2)To perform Cross Validation

3)To do Hyperparameter Tuning

First we head towards model building of different regression models

```
X = k.drop('Downloads_per_thousands_log', axis =1)
y = k['Downloads_per_thousands_log']
X_train, X_test , y_train, y_test = train_test_split(X,y, test_size = 0.3, random_state =


def model_builder(model):

    model.fit(X_train , y_train)
    y_pred = model.predict(X_test)
    r2 = r2_score(y_test , y_pred)
    rmse = np.sqrt(mean_squared_error(y_test , y_pred))
    return(type(model).__name__ , r2, rmse)

models = [LinearRegression(), Lasso() , Ridge(), DecisionTreeRegressor() , SVR() , KNeighb
         AdaBoostRegressor() , GradientBoostingRegressor() , XGBRegressor()]

for m in models:
    model_name, r2, rmse = model_builder(m)
    print(f"{model_name} R2 score: {r2:.3f}")
    print(f"{model_name} Rmse: {rmse:.3f}")
```

```
LinearRegression R2 score: 0.804
LinearRegression Rmse: 1.382
Lasso R2 score: 0.778
Lasso Rmse: 1.470
Ridge R2 score: 0.804
Ridge Rmse: 1.382
DecisionTreeRegressor R2 score: 0.856
DecisionTreeRegressor Rmse: 1.185
SVR R2 score: 0.814
SVR Rmse: 1.346
KNeighborsRegressor R2 score: 0.800
KNeighborsRegressor Rmse: 1.396
RandomForestRegressor R2 score: 0.924
RandomForestRegressor Rmse: 0.858
AdaBoostRegressor R2 score: 0.906
AdaBoostRegressor Rmse: 0.959
GradientBoostingRegressor R2 score: 0.930
GradientBoostingRegressor Rmse: 0.823
```

```
XGBRegressor R2 score: 0.925
XGBRegressor Rmse: 0.857
```

```
def model_builder(model):
    cv_scores = cross_val_score(model, X, y, cv=5, scoring='r2')
    cv_rmse_scores = np.sqrt(-cross_val_score(model, X, y, cv=5, scoring='neg_mean_squared
    return {'Model': type(model).__name__, 'R2 Score': cv_scores.mean(), 'RMSE Score': cv_

models = [LinearRegression(), Lasso() , Ridge(), DecisionTreeRegressor() , SVR() , KNeighb

results = []
for m in models:
    results.append(model_builder(m))

score = pd.DataFrame(results)
print(score)
```

```
                       Model  R2 Score  RMSE Score
0           LinearRegression  0.750373    1.425051
1                      Lasso  0.722147    1.509044
2                      Ridge  0.750375    1.425048
3      DecisionTreeRegressor  0.821875    1.203554
4                        SVR  0.760887    1.395138
5        KNeighborsRegressor  0.733645    1.469008
6      RandomForestRegressor  0.901847    0.891598
7          AdaBoostRegressor  0.884169    0.996853
8  GradientBoostingRegressor  0.910626    0.849862
9               XGBRegressor  0.898702    0.905334
```

```
# XGB, GB and Random forest yeilds the best result . GB gives the best result
```

We will perform hyper prameter tuning on Random Forest Regressor and Gradient Boost Regressor to find the best parameters with the best r2 score.

```
rfr = RandomForestRegressor()
rfr.fit(X_train, y_train)
y_pred = rfr.predict(X_test)
r2 = r2_score(y_test , y_pred)
rmse = np.sqrt(mean_squared_error(y_test , y_pred))
print('r2:', r2)
print('rmse:', rmse)
```

```
r2: 0.9237309459007067
rmse: 0.8619405497646305
```

```
##Check for overfitting
print('Training set score: {:.4f}'.format(rfr.score(X_train, y_train)))

print('Test set score: {:.4f}'.format(rfr.score(X_test, y_test)))
```

```
Training set score: 0.9892
Test set score: 0.9237
```

The model is not overfitting

```
gbr = GradientBoostingRegressor()
gbr.fit(X_train, y_train)
y_pred = gbr.predict(X_test)
r2 = r2_score(y_test , y_pred)
rmse = np.sqrt(mean_squared_error(y_test , y_pred))
print('r2:', r2)
print('rmse:', rmse)
```

```
r2: 0.9304919197805243
rmse: 0.8228502002707806
```

```
#Finding the bet hyprparameters for Random Forest Regressor

param_grid = {'n_estimators': [100, 200],'max_depth': [5, 10],'min_samples_split': [2, 5],
rfr = RandomForestRegressor(random_state=42)
grid_search = GridSearchCV(rfr, param_grid, cv=5, scoring='neg_mean_squared_error')
grid_search.fit(X_train, y_train)

print("Best Hyperparameters:", grid_search.best_params_)
print("Best Score:", np.sqrt(-grid_search.best_score_))
best_rfr = RandomForestRegressor(**grid_search.best_params_, random_state=42)
best_rfr.fit(X_train, y_train)
y_pred = best_rfr.predict(X_test)
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)
rmse = np.sqrt(mse)
print("MSE:", mse)
print("RMSE:", rmse)
print("R2 Score:", r2)
```

```
Best Hyperparameters: {'max_depth': 10, 'min_samples_leaf': 2, 'min_samples_split': 5
Best Score: 0.8475779837375497
MSE: 0.7107849576505462
RMSE: 0.8430806353193899
R2 Score: 0.9270320805051374
```

```
##Finding the bet hyprparameters for Gradient Boost Regressor
param_grid = {'n_estimators': [100, 200],'learning_rate': [0.05, 0.1],'max_depth': [3, 5],
gbr = GradientBoostingRegressor(random_state=42)
grid_search = GridSearchCV(gbr, param_grid, cv=5, scoring='neg_mean_squared_error')
grid_search.fit(X_train, y_train)

print("Best Hyperparameters:", grid_search.best_params_)
print("Best Score:", np.sqrt(-grid_search.best_score_))
best_gbr = GradientBoostingRegressor(**grid_search.best_params_, random_state=42)
```

```
best_gbr.fit(X_train, y_train)
y_pred = best_gbr.predict(X_test)
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)
rmse = np.sqrt(mse)
print("MSE:", mse)
print("RMSE:", rmse)
print("R2 Score:", r2)
```

```
Best Hyperparameters: {'learning_rate': 0.05, 'max_depth': 3, 'min_samples_leaf': 2,
Best Score: 0.836848783330556
MSE: 0.6776933411692802
RMSE: 0.8232213196761125
R2 Score: 0.9304292069937751
```

Post Hyper parameter Tuning Random Forest Regressor gives an R2 score of 0.927 and Gradient Boost Regressor gives an R2 score of 0.93

Now lets try to work on classification to see the accuracy

CLASIFICATION

```
df.head()
```

	App	Category	Rating	Size	Price	Content Rating	Last Updated	Android Ver	Reviews_
0	Photo Editor & Candy Camera & Grid & ScrapBook	0	4.1	19456.0	0.0	1	12.0	4.0	
1	Coloring book moana	0	3.9	14336.0	0.0	1	11.0	4.0	
2	U Launcher Lite – FREE Live Cool Themes, Hide ...	0	4.7	8908.8	0.0	1	5.0	4.0	

```
c = df.drop(['App'], axis = 1)
```

```
scaler = MinMaxScaler()
c['Size_scaled'] = scaler.fit_transform(df[['Size']])
```

```
c = c.drop(['Size'], axis = 1)
c.head(3)
```

	Category	Rating	Price	Content Rating	Last Updated	Android Ver	Reviews_per_thousands
0	0	4.1	0.0	1	12.0	4.0	0.159
1	0	3.9	0.0	1	11.0	4.0	0.967
2	0	4.7	0.0	1	5.0	4.0	87.510

```
c['Downloads']=c['Downloads_per_thousands']*1000
c['Downloads'].unique()
```

```
array([1.e+04, 5.e+05, 5.e+06, 5.e+07, 1.e+05, 5.e+04, 1.e+06, 1.e+07,
       5.e+03, 1.e+08, 1.e+03, 5.e+08, 1.e+02, 5.e+02, 1.e+01, 1.e+09,
       5.e+00, 5.e+01, 1.e+00])
```

```
# Define the bins and categories
bins = [0, 1000, 10000,  100000, 10000000, np.inf]
categories = [0, 1, 2, 3, 4]         # 0 = very low, 1 = low, 2 = medium, 3 = high, 4 = ve

# Bin the values into categories
c['Downloads category'] = pd.cut(c['Downloads'], bins=bins, labels=categories, right=True)

# Print the original and binned data
print(c[['Downloads', 'Downloads category']])
```

```
        Downloads Downloads category
0         10000.0                  1
1        500000.0                  3
2       5000000.0                  3
3      50000000.0                  4
4        100000.0                  2
...           ...                ...
10833      1000.0                  0
10834       500.0                  0
10836      5000.0                  1
10837       100.0                  0
10840  10000000.0                  3

[7025 rows x 2 columns]
```

```
c['Downloads category'].value_counts()
```

```
3    2732
2    1416
1    1360
0    1300
4     217
Name: Downloads category, dtype: int64
```

```
c['Downloads category'] = c['Downloads category'].astype('category').cat.codes.astype(int)
```

```
c.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7025 entries, 0 to 10840
Data columns (total 11 columns):
 #   Column                  Non-Null Count  Dtype  
---  ------                  --------------  -----  
 0   Category                7025 non-null   int64  
 1   Rating                  7025 non-null   float64
 2   Price                   7025 non-null   float64
 3   Content Rating          7025 non-null   int64  
 4   Last Updated            7025 non-null   float64
 5   Android Ver             7025 non-null   float64
 6   Reviews_per_thousands   7025 non-null   float64
 7   Downloads_per_thousands  7025 non-null   float64
 8   Size_scaled             7025 non-null   float64
 9   Downloads               7025 non-null   float64
 10  Downloads category      7025 non-null   int64  
dtypes: float64(8), int64(3)
memory usage: 658.6 KB
```

```
c = c.drop(['Downloads_per_thousands', 'Downloads',], axis = 1)
c.head(2)
```

	Category	Rating	Price	Content Rating	Last Updated	Android Ver	Reviews_per_tho
0	0	4.1	0.0	1	12.0	4.0	
1	0	3.9	0.0	1	11.0	4.0	

```
c = c.drop(['Rating',], axis = 1)
```

```
Xc = c.drop('Downloads category', axis =1)
yc = c['Downloads category']
Xc_train, Xc_test , yc_train, yc_test = train_test_split(Xc,yc, test_size = 0.2, random_st
```

```
print(Xc_train.shape)
print(Xc_test.shape)
print(yc_train.shape)
print(yc_test.shape)
```

```
(5620, 7)
(1405, 7)
(5620,)
(1405,)
```

```
yc_test.value_counts()
```

```
3    532
0    281
2    272
1    271
4     49
Name: Downloads category, dtype: int64
```

```
yc_train.value_counts()
```

```
3    2200
2    1144
1    1089
0    1019
4     168
Name: Downloads category, dtype: int64
```

```
def clf_model_builder(clf_model):

    clf_model.fit(Xc_train , yc_train)
    yc_pred = clf_model.predict(Xc_test)
    accuracy = accuracy_score(yc_test, yc_pred)
    return("Classification accuracy:", accuracy)
```

```
clf_models = [RandomForestClassifier(), AdaBoostClassifier(), GradientBoostingClassifier()
```

```
for model in clf_models:
    print(type(model).__name__)
    print(clf_model_builder(model))
    print()
```

```
RandomForestClassifier
('Classification accuracy:', 0.8177935943060498)

AdaBoostClassifier
('Classification accuracy:', 0.6491103202846975)

GradientBoostingClassifier
('Classification accuracy:', 0.8120996441281139)

DecisionTreeClassifier
('Classification accuracy:', 0.7423487544483985)

SVC
('Classification accuracy:', 0.4185053380782918)
```

```
def clf_model_builder(clf_model):
    cv_scores = cross_val_score(clf_model, Xc, yc, cv=5)
    return("Cross-validation accuracy:", cv_scores.mean())

for model in clf_models:
    print(type(model).__name__)
    print(clf_model_builder(model))
    print()
```

```
RandomForestClassifier
('Cross-validation accuracy:', 0.7971530249110319)

AdaBoostClassifier
('Cross-validation accuracy:', 0.6741637010676157)
```

```
GradientBoostingClassifier
('Cross-validation accuracy:', 0.7965836298932384)

DecisionTreeClassifier
('Cross-validation accuracy:', 0.732526690391459)

SVC
('Cross-validation accuracy:', 0.42889679715302487)
```

Working to further improve model accuracy

```
rfc = RandomForestClassifier(n_estimators=100, random_state=42)
rfc.fit(Xc_train, yc_train)
yc_pred = rfc.predict(Xc_test)
accuracy = accuracy_score(yc_test, yc_pred)
accuracy
```

```
0.8128113879003559
```

```
# Checking for overfitting
print('Training set score: {:.4f}'.format(rfc.score(Xc_train, yc_train)))

print('Test set score: {:.4f}'.format(rfc.score(Xc_test, yc_test)))
```

```
Training set score: 1.0000
Test set score: 0.8128
```

There can be signs of overfitting

```
#Lets perform hyper parameter tuning on the random forest model.
```

```
param_grid = {
    'n_estimators': [100, 200],
    'max_depth': [10, 20, None],
    'min_samples_split': [2, 5],
    'min_samples_leaf': [1, 2, 4],
    'max_features': ['sqrt', 'log2']
    }

grid_search = GridSearchCV(estimator=rfc, param_grid=param_grid, cv=5, n_jobs=-1)

grid_search.fit(Xc_train, yc_train)

print("Best hyperparameters: ", grid_search.best_params_)

yc_pred = grid_search.predict(Xc_test)
accuracy = accuracy_score(yc_test, yc_pred)
print("Test accuracy: ", accuracy)
```