FinalProject

December 10, 2019

[218]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import calendar
from datetime import datetime
from pandas import Series
from math import ceil
import warnings
warnings.filterwarnings('ignore')
df = pd.read_csv('Video_Games_Sales.csv')
```

[218]:
```
Name                 object
Platform             object
Year_of_Release     float64
Genre                object
Publisher            object
NA_Sales            float64
EU_Sales            float64
JP_Sales            float64
Other_Sales         float64
Global_Sales        float64
Critic_Score        float64
Critic_Count        float64
User_Score           object
User_Count          float64
Developer            object
Rating               object
dtype: object
```

0.1 Data Analysis

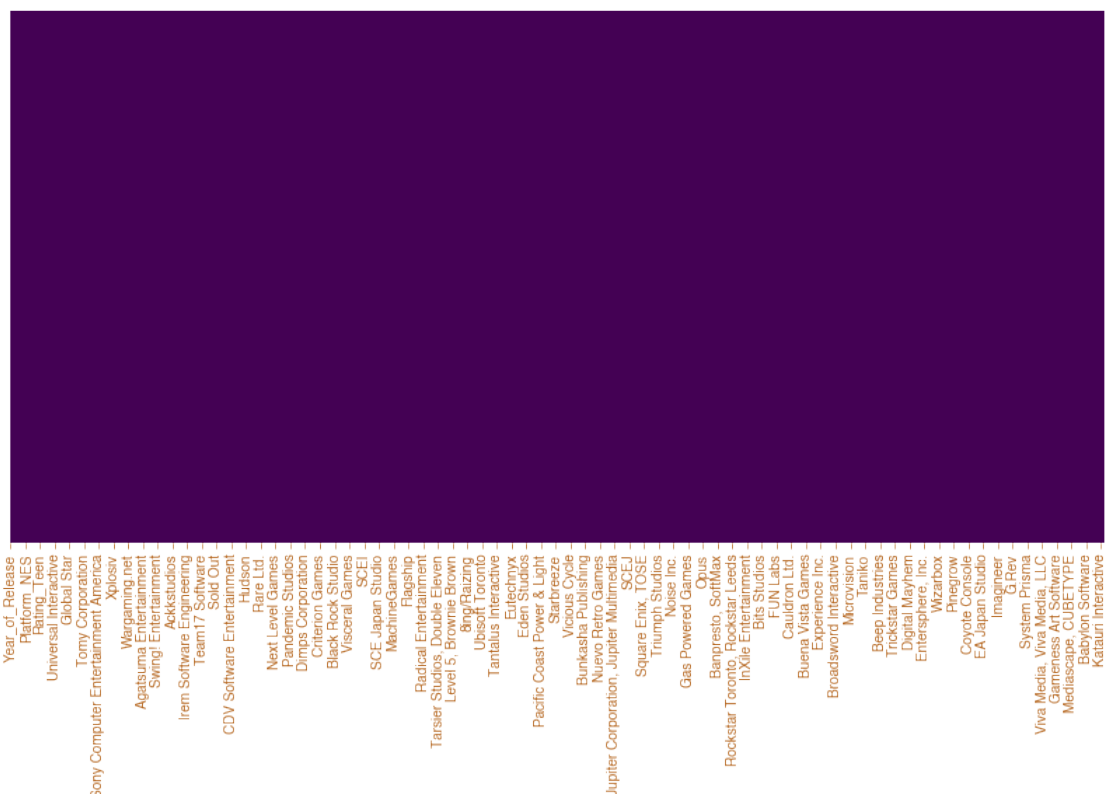
Missing Values Show the missing values distribution:

[217]:
```
plt.figure(figsize=(14,7))
sns.heatmap(df.isnull(),yticklabels=False,cbar=False,cmap='viridis')
df['Global_Sales_Log'] = np.log1p(df['Global_Sales'])
```

```
df['NA_Sales_Log'] = np.log1p(df['NA_Sales'])
df['EU_Sales_Log'] = np.log1p(df['EU_Sales'])
df['JP_Sales_Log'] = np.log1p(df['JP_Sales'])
df['Other_Sales_Log'] = np.log1p(df['Other_Sales'])

null_columns=df.columns[df.isnull().any()]
df[null_columns].isnull().sum()
```

[217]:
```
Year_of_Release                              float64
NA_Sales                                     float64
EU_Sales                                     float64
JP_Sales                                     float64
Other_Sales                                  float64
Global_Sales                                 float64
Platform_XB                                  float64
Platform_X360                                float64
Platform_XOne                                float64
Platform_PC                                  float64
Platform_PS                                  float64
Platform_PS2                                 float64
Platform_PS3                                 float64
Platform_PS4                                 float64
Platform_PSP                                 float64
Platform_PSV                                 float64
Platform_GB                                  float64
Platform_GBA                                 float64
Platform_DS                                  float64
Platform_3DS                                 float64
Platform_NES                                 float64
Platform_SNES                                float64
Platform_N64                                 float64
Platform_GC                                  float64
Platform_Wii                                 float64
Platform_WiiU                                float64
Genre_Action                                 float64
Genre_Adventure                              float64
Genre_Fighting                               float64
Genre_Misc                                   float64
                                              ...
Flying Lab Software                          float64
1C, Ino-Co, 1C Company                       float64
Autumn Moon                                  float64
Tate Interactive                             float64
Elixir Studios                               float64
Compulsion Games                             float64
Camouflaj, LLC                               float64
DMA Design, Rockstar North                   float64
```

```
King of the Jungle                              float64
Spidersoft, Spiders                             float64
Tecmo, Graphic Research                         float64
Battlefront.com, 1C, 1C Company                 float64
EA Phenomic                                     float64
Empty Clip Studios                              float64
Headgate                                        float64
Coffee Stain Studios                            float64
Boston Animation                                float64
React Games                                     float64
Inferno Games                                   float64
Katauri Interactive                             float64
High Moon Studios, Mercenary Technologies       float64
Infinite Dreams, Paragon 5                      float64
Big Red Software                                float64
Fluid Studios                                   float64
Atomic Games                                    float64
Global_Sales_Log                                float64
NA_Sales_Log                                    float64
EU_Sales_Log                                    float64
JP_Sales_Log                                    float64
Other_Sales_Log                                 float64
Length: 1491, dtype: object
```



[186]:
```
# we can see there are lots of missing values in Critic_Score, Critic_Count,
#User_Score etc. While there are ONLY TWO missing in Name and Genre.
```

1 Data Cleaning

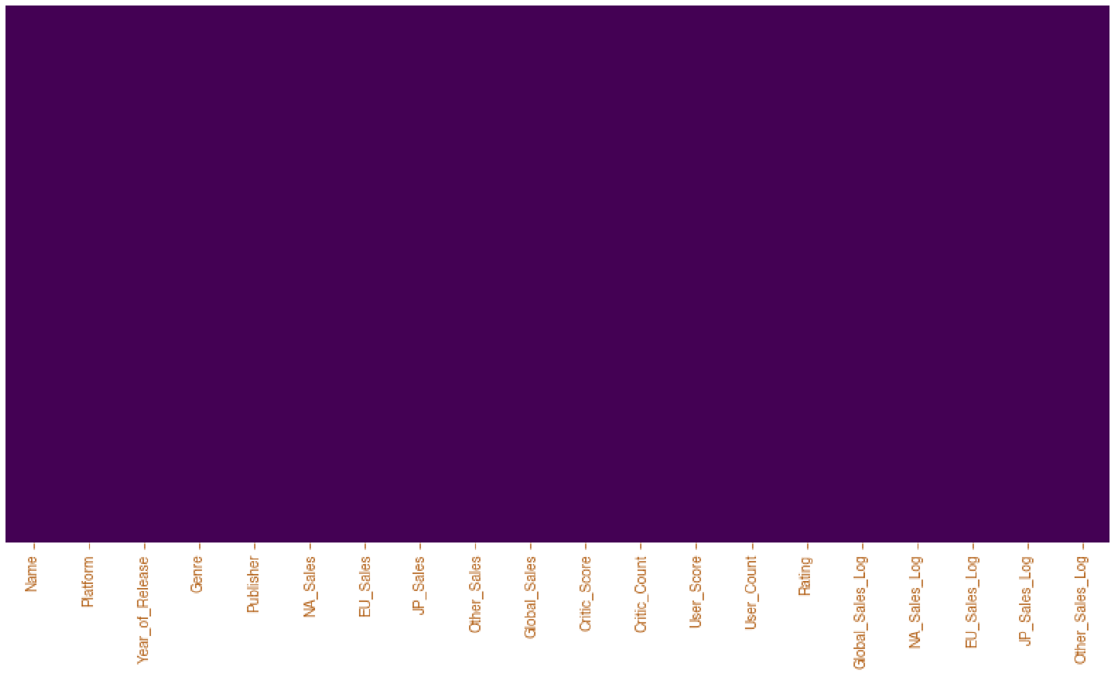
[187]:
```
df.drop(index=[659,14246],inplace=True)
df[df.Year_of_Release.isnull()]
df.Year_of_Release = df.Year_of_Release.fillna(0)
df[df['Year_of_Release']==0].Platform.unique()

PS2_median = df[df['Platform'] == 'PS2']['Year_of_Release'].median()
Wii_median = df[df['Platform'] == 'Wii']['Year_of_Release'].median()
x2600median = df[df['Platform'] == '2600']['Year_of_Release'].median()
X360_median = df[df['Platform'] == 'X360']['Year_of_Release'].median()
GBA_median = df[df['Platform'] == 'GBA']['Year_of_Release'].median()
PC_median = df[df['Platform'] == 'PC']['Year_of_Release'].median()
PS3_median = df[df['Platform'] == 'PS3']['Year_of_Release'].median()
PS_median = df[df['Platform'] == 'PS']['Year_of_Release'].median()
PSP_median = df[df['Platform'] == 'PSP']['Year_of_Release'].median()
XB_median = df[df['Platform'] == 'XB']['Year_of_Release'].median()
GB_median = df[df['Platform'] == 'GB']['Year_of_Release'].median()
DS_median = df[df['Platform'] == 'DS']['Year_of_Release'].median()
x3DS_median = df[df['Platform'] == '3DS']['Year_of_Release'].median()
N64_median = df[df['Platform'] == 'N64']['Year_of_Release'].median()
PSV_median = df[df['Platform'] == 'PSV']['Year_of_Release'].median()
GC_median = df[df['Platform'] == 'GC']['Year_of_Release'].median()


# Function that returns the median of the platform if year = 0. Else it returns
↪the year.
def year_filler(x):

    if x.Year_of_Release == 0:
        if x.Platform == 'PS2':
            return PS2_median
        elif x.Platform == 'Wii':
            return Wii_median
        elif x.Platform == '2600':
            return x2600median
        elif x.Platform == 'X360':
            return X360_median
        elif x.Platform == 'GBA':
            return GBA_median
        elif x.Platform == 'PC':
            return PC_median
```

```
        elif x.Platform == 'PS3':
            return PS3_median
        elif x.Platform == 'PS':
            return PS_median
        elif x.Platform == 'PSP':
            return PSP_median
        elif x.Platform == 'XB':
            return XB_median
        elif x.Platform == 'GB':
            return GB_median
        elif x.Platform == 'DS':
            return DS_median
        elif x.Platform == '3DS':
            return x3DS_median
        elif x.Platform == 'N64':
            return N64_median
        elif x.Platform == 'PSV':
            return PSV_median
        elif x.Platform == 'GC':
            return GC_median
        else:
            return 1900
    else:
        return x.Year_of_Release


# apply function to replace values
df.Year_of_Release = df.apply(year_filler, axis=1)

df['Publisher'].fillna(value='Unknown', inplace=True)
# We will start by filling the missing values of Critic_Score and Critic_Count.
df.Critic_Score = df.Critic_Score.fillna(df.Critic_Score.median())
df.Critic_Count = df.Critic_Count.fillna(df.Critic_Count.median())

# We will start by filling the missing values of Critic_Score and Critic_Count.
# Because Critic_Score has NaN values, we will first fill those NaN values with␣
 ↪0.

df.User_Score = df.User_Score.fillna(0)


# Some values of Critic_Score have the value'tbd'. These values need to be␣
 ↪replaces with 100.
df.User_Score.replace(to_replace='tbd',value=100,inplace=True)

# We will do the same for User_Count
df.User_Count = df.User_Count.fillna(df.User_Count.median())
```

```
# Replace the missing values of Rating with Unknown.
df.Rating.fillna('Unknown',inplace=True)

# Because Developer has too many unique values, we will drop this column.
df.drop('Developer',axis=1,inplace=True)

columns = df.columns
percent_missing = df.isnull().sum() * 100 / len(df)
missing_value_df = pd.DataFrame({'column_name': columns,
                                 'percent_missing': percent_missing})
print(missing_value_df)


### Missing Values Show the missing values distribution:
plt.figure(figsize=(14,7))
sns.heatmap(df.isnull(),yticklabels=False,cbar=False,cmap='viridis')
df['Global_Sales_Log'] = np.log1p(df['Global_Sales'])

df['NA_Sales_Log'] = np.log1p(df['NA_Sales'])
df['EU_Sales_Log'] = np.log1p(df['EU_Sales'])
df['JP_Sales_Log'] = np.log1p(df['JP_Sales'])
df['Other_Sales_Log'] = np.log1p(df['Other_Sales'])

null_columns=df.columns[df.isnull().any()]
df[null_columns].isnull().sum()

dforiginal=df;
```

```
                      column_name  percent_missing
Name                         Name              0.0
Platform                 Platform              0.0
Year_of_Release   Year_of_Release              0.0
Genre                       Genre              0.0
Publisher               Publisher              0.0
NA_Sales                 NA_Sales              0.0
EU_Sales                 EU_Sales              0.0
JP_Sales                 JP_Sales              0.0
Other_Sales           Other_Sales              0.0
Global_Sales         Global_Sales              0.0
Critic_Score         Critic_Score              0.0
Critic_Count         Critic_Count              0.0
User_Score             User_Score              0.0
User_Count             User_Count              0.0
Rating                     Rating              0.0
Global_Sales_Log Global_Sales_Log              0.0
NA_Sales_Log         NA_Sales_Log              0.0
```

```
EU_Sales_Log          EU_Sales_Log             0.0
JP_Sales_Log          JP_Sales_Log             0.0
Other_Sales_Log    Other_Sales_Log             0.0
```

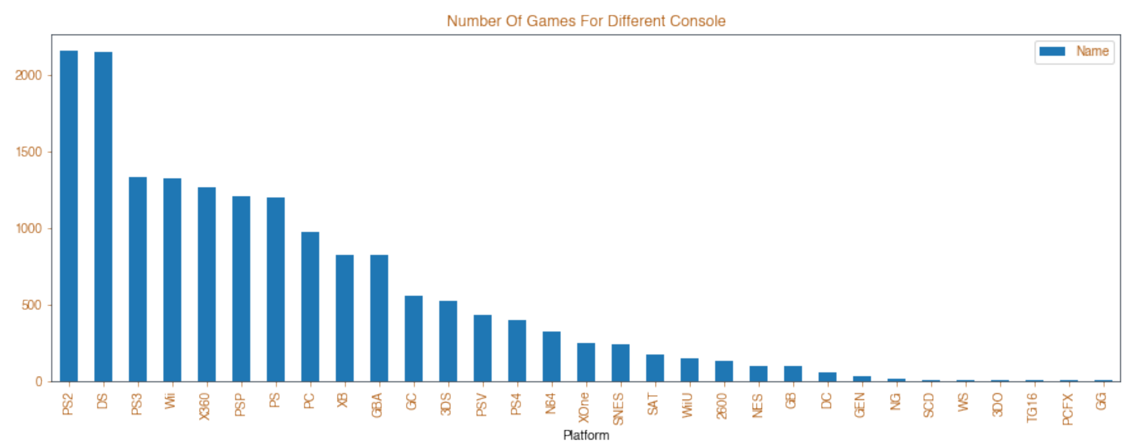


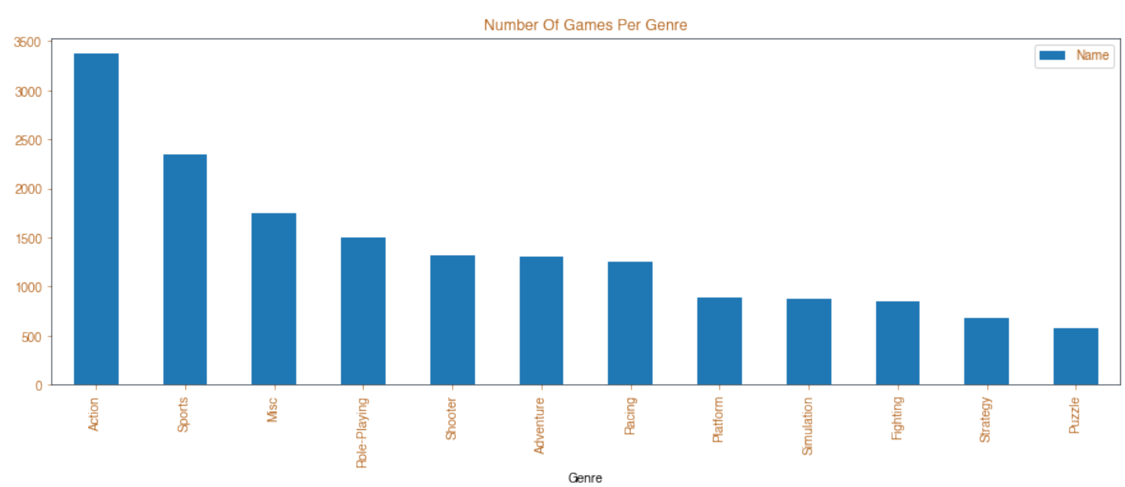
2 Data Analysis & Data visualization:

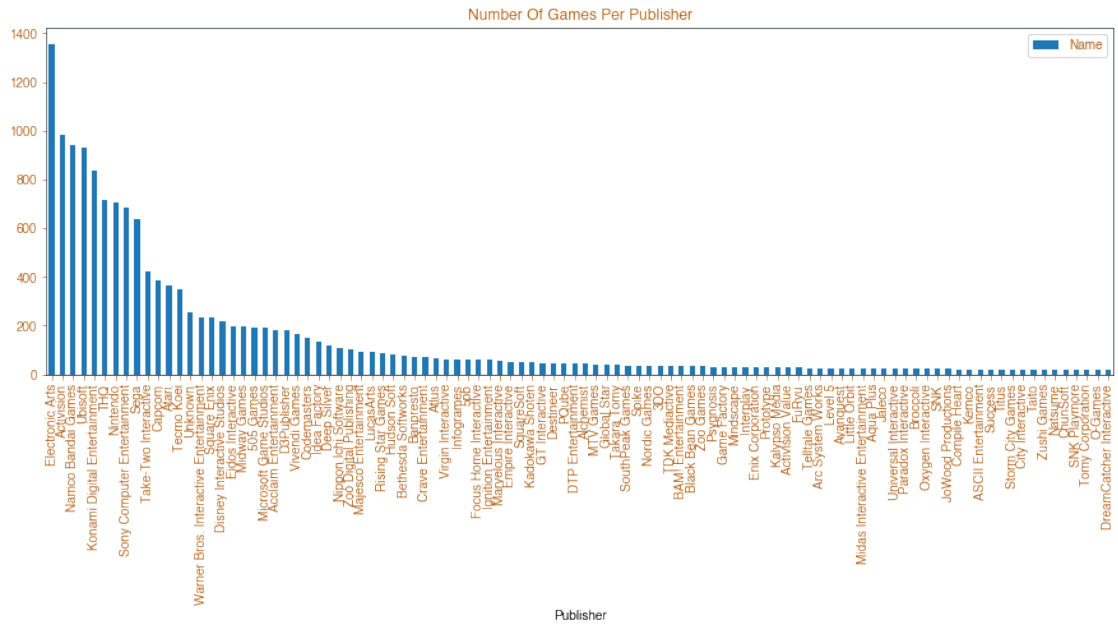
[188]:
```python
#Plot Top values in the dataset By platform, developer and genre.
import matplotlib.pyplot as plt
%matplotlib inline

# set font
plt.rcParams['font.family'] = 'sans-serif'
plt.rcParams['font.sans-serif'] = 'Helvetica'

# set the style of the axes and the text color
plt.rcParams['axes.edgecolor']='#333F4B'
plt.rcParams['axes.linewidth']=0.8
plt.rcParams['xtick.color']='#b5651d'
plt.rcParams['ytick.color']='#b5651d'
plt.rcParams['text.color']='#b5651d'
plt.rcParams['figure.figsize'] = 15, 5
```

```
namePlatformDf = df[['Name', 'Platform']].groupby(['Platform']).count().
 ↪sort_values('Name', ascending=False).reset_index()
namePlatformDf.plot(kind='bar', x="Platform", y="Name",title="Number Of Games␣
 ↪For Different Console")

nameGenreDf = df[['Name', 'Genre']].groupby(['Genre']).count().
 ↪sort_values('Name', ascending=False).reset_index()
nameGenreDf.plot(kind='bar', x="Genre", y="Name",title="Number Of Games Per␣
 ↪Genre")

nameDeveloperDf = df[['Name', 'Publisher']].groupby(['Publisher']).count().
 ↪sort_values('Name', ascending=False).reset_index()
nameDeveloperDf[:100].plot(kind='bar', x="Publisher", y="Name",title="Number Of␣
 ↪Games Per Publisher")
```

[188]: <matplotlib.axes._subplots.AxesSubplot at 0x1a23eeacc0>

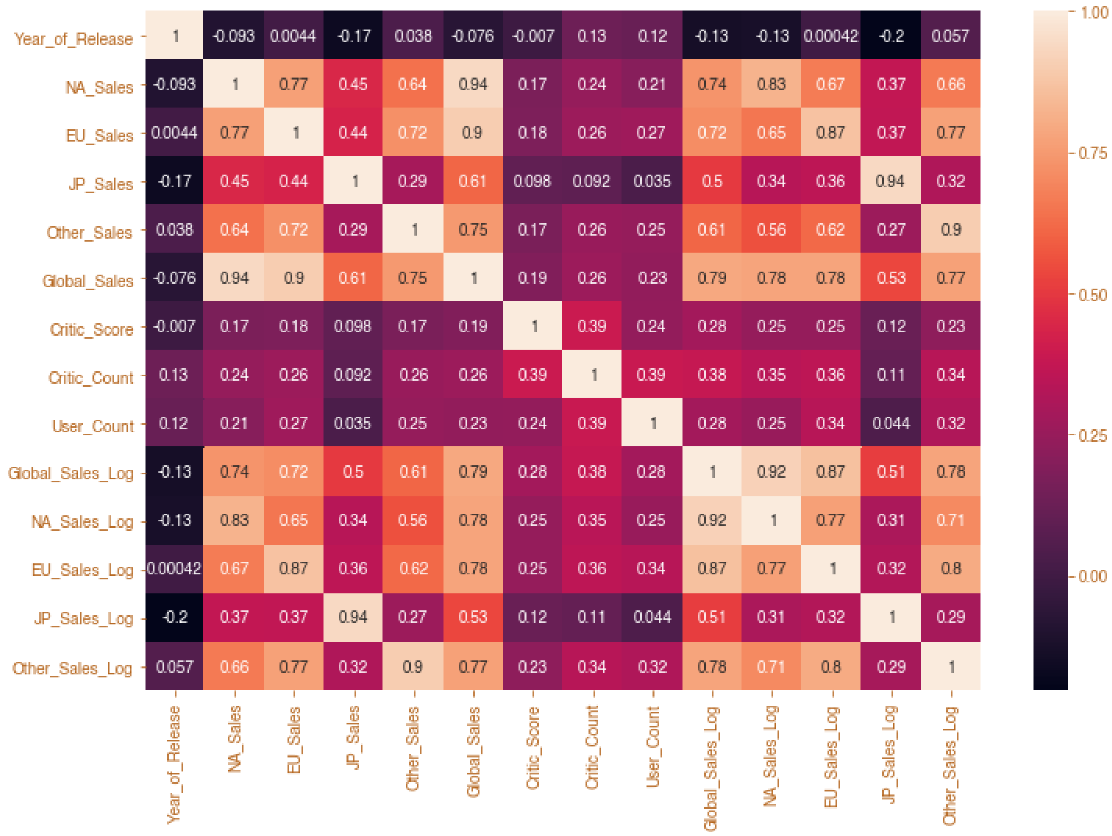






DATA CORRELATION

[189]:
```
plt.figure(figsize=(12, 8))

vg_corr = df.corr()
sns.heatmap(vg_corr,
            xticklabels = vg_corr.columns.values,
            yticklabels = vg_corr.columns.values,
            annot = True);
```



[190]:
```
## UTITLITY FUNCTION FOR PRINTING CLASSIFICATION REPORT
```

[191]:
```
import seaborn as sns
import numpy as np
from sklearn.metrics import precision_recall_fscore_support
import matplotlib.pyplot as plt

y = np.random.randint(low=0, high=10, size=100)
y_p = np.random.randint(low=0, high=10, size=100)

def plot_classification_report(y_tru, y_prd, figsize=(10, 10), ax=None):

    plt.figure(figsize=figsize)

    xticks = ['precision', 'recall', 'f1-score', 'support']
    yticks = list(np.unique(y_tru))
    yticks += ['avg']

    rep = np.array(precision_recall_fscore_support(y_tru, y_prd)).T
    avg = np.mean(rep, axis=0)
    avg[-1] = np.sum(rep[:, -1])
    rep = np.insert(rep, rep.shape[0], avg, axis=0)
```

```
    sns.heatmap(rep,
                annot=True,
                cbar=False,
                xticklabels=xticks,
                yticklabels=yticks,
                ax=ax)
```

[192]:
```
## UTITLITY FUNCTION FOR PRINTING CONFUSION MATRIX
```

[193]:
```
import itertools
import matplotlib.pyplot as plt
import numpy as np
from sklearn.metrics import confusion_matrix

# Source: http://scikit-learn.org/stable/auto_examples/model_selection/
#          plot_confusion_matrix.html#confusion-matrix

def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    print(cm)

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)

    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")
    plt.tight_layout()
```

```
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

[194]:
```
# Data Transformation

df.drop(index=[0], inplace=True)

#Transform datatypeschange the datatypefrom real number -> integer
# Transform year from float to integer
df['Year_of_Release'] = df.Year_of_Release.astype(int)

# Transform Critic_Score from float to integer
df['Critic_Score'] = df.Critic_Score.astype(int)

# Transform Critic_Count from float to integer
df['Critic_Count'] = df.Critic_Count.astype(int)

# Transform User_Count from float to integer
df['User_Count'] = df.User_Count.astype(int)


# Transform User_Score to int
df.User_Score = pd.to_numeric(df.User_Score, errors='coerce')
```

[195]:
```
# Categorical encoding and standardization
# First we will create a new feature, based on the year of release.
# The new feature 'years_after_release' = year of release - release date of the␣
↪platform

# Create new, empty column
df['year_after_release'] = ''

# Create variables for all console relese years
PS2_release = 2000
Wii_release = 2006
x2600_release = 1977
X360_release = 2005
GBA_release = 2001
PS3_release = 2006
PS_release = 1994
PSP_release = 2004
XB_release = 2001
GB_release = 1989
DS_release = 2004
x3DS_release = 2011
N64_release = 1996
PSV_release = 2011
GC_release = 2001
```

```
def year_after_release_filler(x):

        if x.Platform == 'PS2':
            return x.Year_of_Release - PS2_release
        elif x.Platform == 'Wii':
            return x.Year_of_Release - Wii_release
        elif x.Platform == '2600':
            return x.Year_of_Release - x2600_release
        elif x.Platform == 'X360':
            return x.Year_of_Release - X360_release
        elif x.Platform == 'GBA':
            return x.Year_of_Release - GBA_release
        elif x.Platform == 'PS3':
            return x.Year_of_Release - PS3_release
        elif x.Platform == 'PS':
            return x.Year_of_Release - PS_release
        elif x.Platform == 'PSP':
            return x.Year_of_Release - PSP_release
        elif x.Platform == 'XB':
            return x.Year_of_Release - XB_release
        elif x.Platform == 'GB':
            return x.Year_of_Release - GB_release
        elif x.Platform == 'DS':
            return x.Year_of_Release - DS_release
        elif x.Platform == '3DS':
            return x.Year_of_Release - x3DS_release
        elif x.Platform == 'N64':
            return x.Year_of_Release - N64_release
        elif x.Platform == 'PSV':
            return x.Year_of_Release - PSV_release
        elif x.Platform == 'GC':
            return x.Year_of_Release - GC_release
        else:
            return 1


df.year_after_release = df.apply(year_after_release_filler, axis=1)
df.drop(index=[15959],inplace=True)
df[df['year_after_release'] <0]
```

[195]:

```
                                         Name Platform  Year_of_Release  \
1340                        Disney's DuckTales       GB             1988
2076                            NFL Fever 2002       XB             2000
12301  ESPN Winter X-Games: Snowboarding 2002      GBA             2000
```

```
          Genre                     Publisher  NA_Sales  EU_Sales  JP_Sales  \
1340   Platform                       Capcom      0.82      0.23      0.35
2076     Sports       Microsoft Game Studios      0.74      0.21      0.00
12301    Sports  Konami Digital Entertainment      0.05      0.02      0.00

       Other_Sales  Global_Sales  ...  Critic_Count  User_Score  User_Count  \
1340          0.03          1.43  ...            21         0.0          24
2076          0.04          0.99  ...            24         8.5          10
12301         0.00          0.06  ...            21         0.0          24

        Rating Global_Sales_Log  NA_Sales_Log  EU_Sales_Log  JP_Sales_Log  \
1340   Unknown         0.887891      0.598837      0.207014      0.300105
2076         E         0.688135      0.553885      0.190620      0.000000
12301  Unknown         0.058269      0.048790      0.019803      0.000000

       Other_Sales_Log  year_after_release
1340          0.029559                  -1
2076          0.039221                  -1
12301         0.000000                  -1

[3 rows x 21 columns]
```

2.0.1 Learning(Training) and Evaluation(Testing)

2.0.2 Split Train Cases and Test Cases

[196]:
```python
# Split training-test data
# For the first ML models, we will use 'Global_Sales_Log' as the target variable.

# Standardizing numerical features
# User_Score features that need to be standardized are: Critic_Score, Critic_Count, User_Count, year_after_release

df10=df

# Encoding categorical features
# We will now create dummy variables for Platform, Genre, Publisher and Rating.

df_dummies = pd.get_dummies(df10[['Platform','Genre','Publisher','Rating']], drop_first = True)
# Merge the dummies dataframe with the original dataframe
df10 = pd.merge(df_dummies, df10, left_index=True, right_index=True)


from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
```

```python
print(df10.columns)
scaled_features = scaler.fit_transform(df10[['Critic_Score',␣
 ↪'Critic_Count','User_Score','User_Count','year_after_release']])
scaled_df = pd.DataFrame(scaled_features, columns=['Critic_Score',␣
 ↪'Critic_Count','User_Score','User_Count','year_after_release'])

df10 = pd.merge(scaled_df, df, left_index=True, right_index=True)


# # Drop original non-standardized features
columns = ['Critic_Score_y',␣
 ↪'Critic_Count_y','User_Score_y','User_Count_y','NA_Sales',␣
 ↪'EU_Sales','JP_Sales','Other_Sales','Global_Sales','year_after_release_y']
df10.drop(columns, inplace=True, axis=1)

X = df10.
 ↪drop(['Global_Sales_Log','NA_Sales_Log','EU_Sales_Log','JP_Sales_Log','Other_Sales_Log'],␣
 ↪axis=1)
y = df10['Global_Sales_Log']
X=df10[['Critic_Score_x', 'Critic_Count_x', 'User_Score_x', 'User_Count_x',␣
 ↪'year_after_release_x', 'NA_Sales_Log']]
```

```
Index(['Platform_3DO', 'Platform_3DS', 'Platform_DC', 'Platform_DS',
       'Platform_GB', 'Platform_GBA', 'Platform_GC', 'Platform_GEN',
       'Platform_GG', 'Platform_N64',
       ...
       'Critic_Count', 'User_Score', 'User_Count', 'Rating',
       'Global_Sales_Log', 'NA_Sales_Log', 'EU_Sales_Log', 'JP_Sales_Log',
       'Other_Sales_Log', 'year_after_release'],
      dtype='object', length=649)
```

[197]:
```python
##Learning and evaluation

from sklearn.model_selection import KFold
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,␣
 ↪random_state=101)



from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import learning_curve
```

2.1 1.First ML Problem

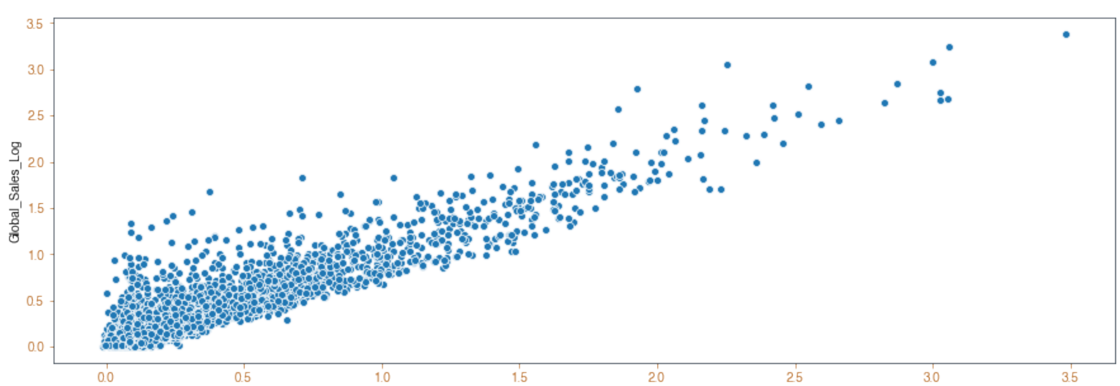
X=> Critic_Score_x', 'Critic_Count_x', 'User_Score_x', 'User_Count_x', 'year_after_release_x'

y=> Global_Sales_Log

1.Linear Regression

[222]:
```
# 1.Linear Regression

from sklearn.linear_model import LinearRegression

lr = LinearRegression()
lr.fit(X_train,y_train)
lr_predictions = lr.predict(X_test)
# Evaluate model
from sklearn.metrics import explained_variance_score, mean_squared_error,␣
↪mean_absolute_error

sns.scatterplot(lr_predictions,y_test)

MAE_lr = mean_absolute_error(y_test, lr_predictions)
MSE_lr = mean_squared_error(y_test, lr_predictions)
var_lr = explained_variance_score(y_test, lr_predictions)

print("accuracy :" + str(lr.score(X_test,y_test)))
print("mean_absolute_error :" + str(MAE_lr))
print("mean_squared_error :" + str(MSE_lr))
print("variance_score :" + str(var_lr))
```

```
accuracy :0.8523184660252421
mean_absolute_error :0.09902835743695935
mean_squared_error :0.02286022063308966
variance_score :0.8523184741545611
```

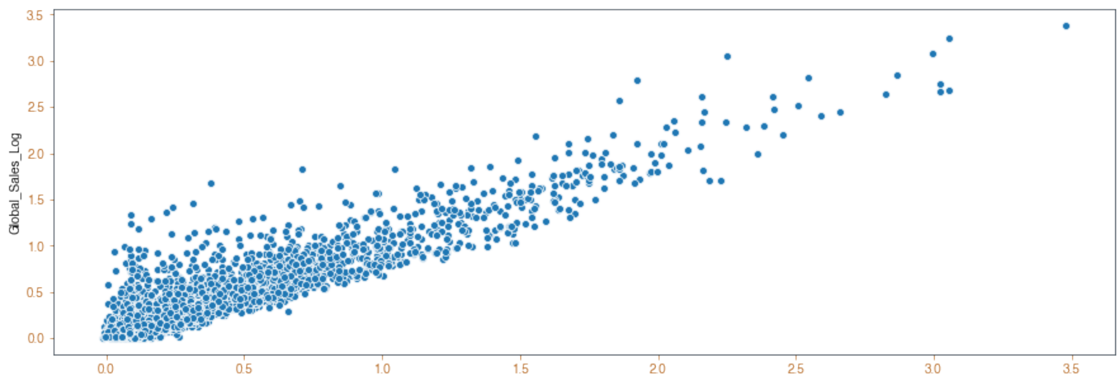


2. Ridge Regression

[223]:
```
# 2. Ridge Regression

from sklearn.linear_model import Ridge

ridge = Ridge()
parameters = {'alpha':[0.001,0.005,0.01,0.1,0.5,1], 'normalize':[True,False],␣
↪'tol':[1e-06,5e-06,1e-05,5e-05]}
grid_ridge = GridSearchCV(ridge, parameters, cv=10, verbose=1, scoring =␣
↪'explained_variance')
grid_ridge.fit(X_train, y_train)

print(grid_ridge.best_score_)
print(grid_ridge.best_params_)

ridge_optimized = Ridge(alpha= 1, normalize= False, tol=1e-06)

ridge_optimized.fit(X_train,y_train)

ridge_pred = ridge_optimized.predict(X_test)

MAE_ridge = mean_absolute_error(y_test, ridge_pred)
MSE_ridge = mean_squared_error(y_test, ridge_pred)
var_ridge = explained_variance_score(y_test, ridge_pred)
print("mean_absolute_error :" + str(MAE_ridge))
print("mean_squared_error :" + str(MSE_ridge))
print("variance :" + str(var_ridge))
print("accuracy :" + str(ridge_optimized.score(X_test,y_test)))
sns.scatterplot(ridge_pred,y_test)
```

```
Fitting 10 folds for each of 48 candidates, totalling 480 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.

0.8434304695922168
{'alpha': 0.1, 'normalize': False, 'tol': 1e-06}
mean_absolute_error :0.09908128080265304
mean_squared_error :0.022863384030535606
variance :0.8522980350467355
accuracy :0.8522980298538295

[Parallel(n_jobs=1)]: Done 480 out of 480 | elapsed:    1.3s finished
```

[223]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a237acb38>
```



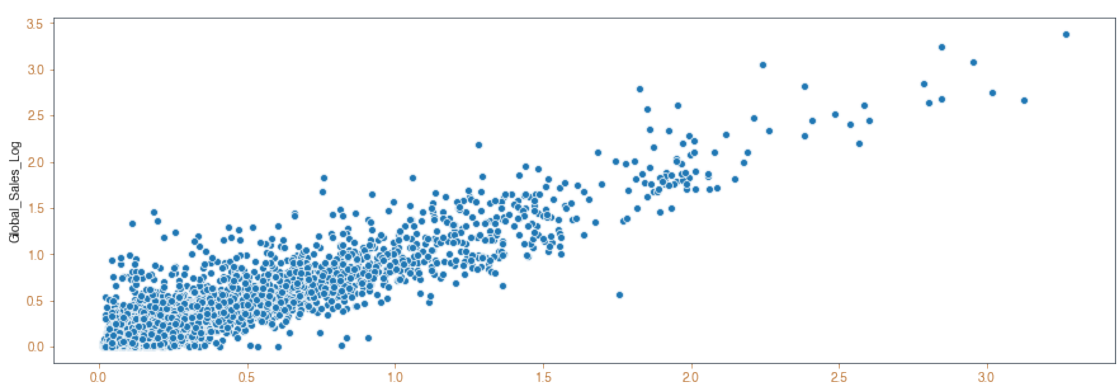
3. RandomForest Regression

[226]:
```python
from sklearn.ensemble import RandomForestRegressor
rf = RandomForestRegressor()
rf.fit(X_train,y_train)
rf_predictions = rf.predict(X_test)
MAE_rf = mean_absolute_error(y_test, rf_predictions)
MSE_rf = mean_squared_error(y_test, rf_predictions)
print("mae: " + str(MAE_rf))
print("mse: " + str(MSE_rf))
print("accuracy :" + str(rf.score(X_test,y_test)))
print("variance :" + str(explained_variance_score(y_test, rf_predictions)))
```

```
mae: 0.09884309984717227
mse: 0.02510867527810916
accuracy :0.8377930055592785
variance :0.8379337860864112
```

[201]:
```python
sns.scatterplot(rf_predictions,y_test)
```

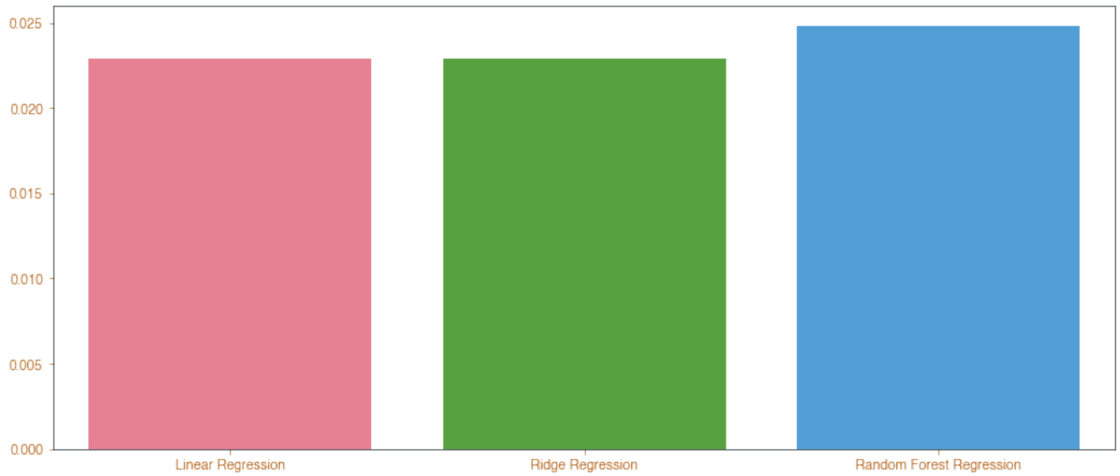
[201]: <matplotlib.axes._subplots.AxesSubplot at 0x1a1be7a2b0>



2.1.1 Evaluate different models

[202]:
```
# # Comparison of MSE of the models
MSEs = [0.022860,0.022863,0.02479]

models = ['Linear Regression','Ridge Regression','Random Forest Regression']
plt.figure(figsize=(14,6))
sns.barplot(models,MSEs,palette='husl')
```

[202]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a1cc63d68>
```



2.1.2 2. Second ML Problem

X=> Year_of_Release Critic_Score

y=> Hit

2.1.3 RandomForestClassifier,LogisticRegression

[231]:
```
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, f1_score, accuracy_score,␣
↪confusion_matrix
from sklearn import svm
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_auc_score
from sklearn.metrics import classification_report
```

```
dfa= df.copy()
dfb =␣
↪dfa[['Name','Platform','Genre','Publisher','Year_of_Release','Critic_Score','Global_Sales']]
dfb = dfb.dropna().reset_index(drop=True)
df2 =␣
↪dfb[['Platform','Genre','Publisher','Year_of_Release','Critic_Score','Global_Sales']]
df2['Hit'] = df2['Global_Sales']
df2.drop('Global_Sales', axis=1, inplace=True)


def hit(sales):
    if sales >= 1:
        return 1
    else:
        return 0

df2['Hit'] = df2['Hit'].apply(lambda x: hit(x))

df3 = df2[['Year_of_Release','Critic_Score','Hit']]
y = df3['Hit'].values
df3 = df3.drop(['Hit'],axis=1)
X = df3.values

Xtrain, Xtest, ytrain, ytest = train_test_split(X, y, test_size=0.50,␣
↪random_state=2)

print('X Year_of_Release Critic_Score')
print('Y Hit')

radm = RandomForestClassifier(random_state=2).fit(Xtrain, ytrain)
y_val_1 = radm.predict_proba(Xtest)
ypred3 = radm.predict(Xtest)

print("Validation accuracy with RandomForestClassifier: %0.2f"␣
↪%(accuracy_score(ytest, ypred3)))

MAE_rf = mean_absolute_error(ytest, ypred3)
MSE_rf = mean_squared_error(ytest, ypred3)
print("mae for RandomForestClassifier: " + str(MAE_rf))
print("mse for RandomForestClassifier: " + str(MSE_rf))
print("accuracy for RandomForestClassifier:" + str(radm.score(Xtest,ytest)))
print("variance for RandomForestClassifier :" +␣
↪str(explained_variance_score(ytest, ypred3)))

log_reg = LogisticRegression().fit(Xtrain, ytrain)
y_val_2 = log_reg.predict_proba(Xtest)
ypred = log_reg.predict(Xtest)
```

```
print("Validation accuracy with LogisticRegression: %0.2f"␣
↪%(accuracy_score(ytest, ypred)))

print('Regression on training set:',log_reg.score(Xtrain, ytrain))
print('Regression Score on test set:',log_reg.score(Xtest, ytest))

print("mae for LogisticRegression: " + str(mean_absolute_error(ytest, ypred)))
print("mse for LogisticRegression: " + str(mean_squared_error(ytest, ypred)))
print("accuracy for LogisticRegression:" + str(log_reg.score(Xtest,ytest)))
print("variance for LogisticRegression :" + str(explained_variance_score(ytest,␣
↪ypred)))


from sklearn.linear_model import LinearRegression

LR = LinearRegression()
model = LR.fit(Xtrain, ytrain)
pd.DataFrame({'features': df3.columns, 'estimatedCoefficients': model.
↪coef_})[['features', 'estimatedCoefficients']].
↪sort_values(by='estimatedCoefficients', ascending=False)
```

```
X Year_of_Release Critic_Score
Y Hit
Validation accuracy with RandomForestClassifier: 0.82
mae for RandomForestClassifier: 0.18015534953645704
mse for RandomForestClassifier: 0.18015534953645704
accuracy for RandomForestClassifier:0.8198446504635429
variance for RandomForestClassifier :-0.20697724448893373
Validation accuracy with LogisticRegression: 0.83
Regression on training set: 0.8466549736908043
Regression Score on test set: 0.8338762214983714
mae for LogisticRegression: 0.16612377850162866
mse for LogisticRegression: 0.16612377850162866
accuracy for LogisticRegression:0.8338762214983714
variance for LogisticRegression :0.014201230193749192
```

[231]:

	features	estimatedCoefficients
1	Critic_Score	0.008154
0	Year_of_Release	0.002191

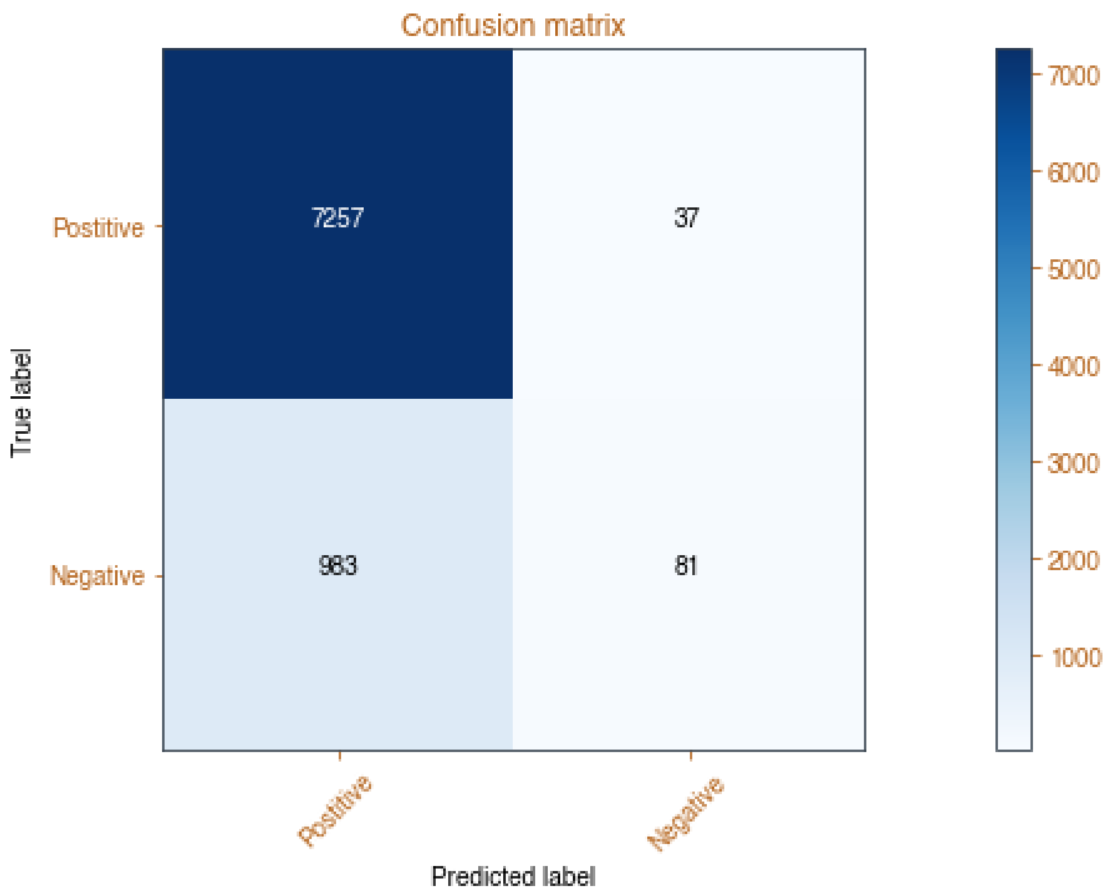
Confusion Matrix, Classification Report,ROC curve

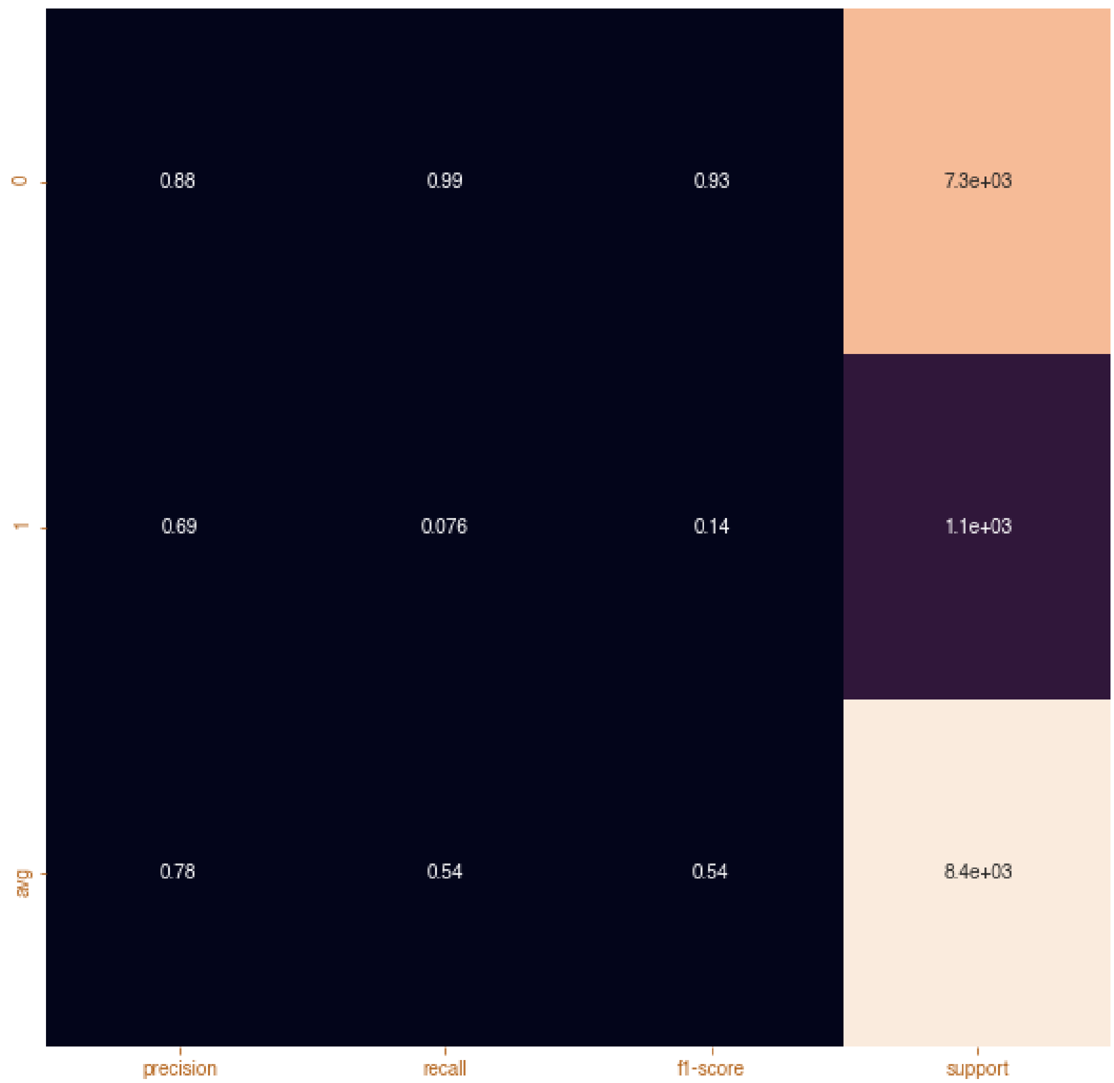
[204]:
```
from sklearn import metrics
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
```

```python
ypred = log_reg.predict(Xtest)
print("Confusion Matrix")
print(confusion_matrix(ytest, ypred))
cm = confusion_matrix(ytest, ypred)
np.set_printoptions(precision=2)
plt.figure()
plot_confusion_matrix(cm, classes=["Postitive", "Negative"],
                      title='Confusion matrix')

print("Classification Report")
print(classification_report(ytest, ypred))
plot_classification_report(ytest, ypred)

logit_roc_auc = roc_auc_score(ytest, ypred)
print("Logistic AUC = %0.2f" %logit_roc_auc)

b = log_reg.predict_proba(Xtest)[:,1]
print(b[0:5])
fpr, tpr, threshold = roc_curve(ytest, b)

# plotting ROC curve
import matplotlib.pyplot as plt
plt.figure()
plt.plot(fpr, tpr, label='ROC curve (area = %0.2f)' %logit_roc_auc)
plt.plot([0,1], [0,1], 'k--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic example')
plt.legend(loc="lower right")
plt.show()
```

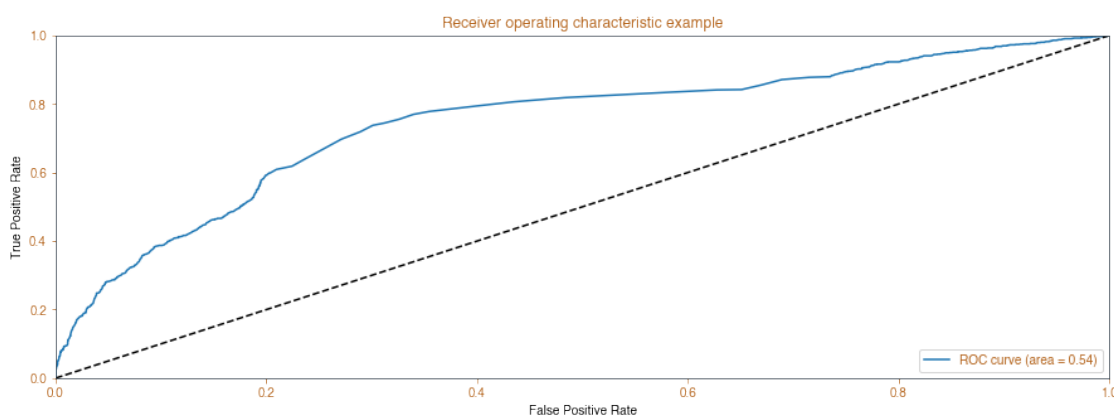
```
Confusion Matrix
[[7257   37]
 [ 983   81]]
Confusion matrix, without normalization
[[7257   37]
 [ 983   81]]
Classification Report
              precision    recall  f1-score   support

           0       0.88      0.99      0.93      7294
           1       0.69      0.08      0.14      1064

    accuracy                           0.88      8358
   macro avg       0.78      0.54      0.54      8358
```

```
weighted avg       0.86      0.88      0.83      8358

Logistic AUC = 0.54
[0.1  0.09 0.05 0.16 0.1 ]
```





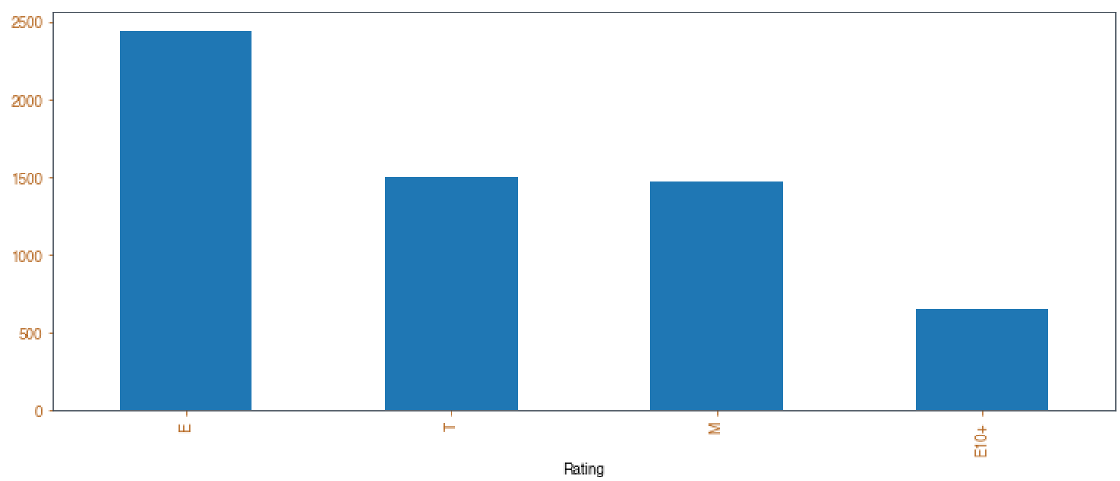
0
1
avg
0.88
0.99
0.93
7.3e+03
0.69
0.076
0.14
1.1e+03
0.78
0.54
0.54
8.4e+03
precision
recall
f1-score
support



Receiver operating characteristic example
True Positive Rate
False Positive Rate
ROC curve (area = 0.54)
0.0
0.2
0.4
0.6
0.8
1.0

Data Analysis for Ratings. Encoding Ratings and clean up.

[205]:
```
df = pd.read_csv('Video_Games_Sales.csv', encoding="utf-8")
df = df[df.Rating != "RP"]
df = df[df.Rating != "EC"]
df = df[df.Rating != "AO"]
df = df[df.Rating != "K-A"]

ax = df.groupby('Rating').sum().unstack().Global_Sales.
↪sort_values(ascending=False).head(10).plot(kind='bar',
                                                                    ␣
↪                          figsize=(
                                                                    ␣
↪                           13, 5));
```



[206]:
```
df = pd.read_csv('Video_Games_Sales.csv', encoding="utf-8")
df = df[df.Platform != "2600"]
df = df[df.Platform != "3DO"]
df = df[df.Platform != "DC"]
df = df[df.Platform != "GEN"]
df = df[df.Platform != "GG"]
df = df[df.Platform != "NG"]
df = df[df.Platform != "PCFX"]
df = df[df.Platform != "SAT"]
df = df[df.Platform != "SCD"]
df = df[df.Platform != "TG16"]
df = df[df.Platform != "WS"]


df = df[df.User_Score != "tbd"]
df = df.dropna().reset_index(drop=True)
```

```
    df["Platform_XB"] = 0
    df["Platform_X360"] = 0
    df["Platform_XOne"] = 0
    df["Platform_PC"] = 0
    df["Platform_PS"] = 0
    df["Platform_PS2"] = 0
    df["Platform_PS3"] = 0
    df["Platform_PS4"] = 0
    df["Platform_PSP"] = 0
    df["Platform_PSV"] = 0
    df["Platform_GB"] = 0
    df["Platform_GBA"] = 0
    df["Platform_DS"] = 0
    df["Platform_3DS"] = 0
    df["Platform_NES"] = 0
    df["Platform_SNES"] = 0
    df["Platform_N64"] = 0
    df["Platform_GC"] = 0
    df["Platform_Wii"] = 0
    df["Platform_WiiU"] = 0

    for elem in df.index.get_values():
        if df.get_value(elem, "Platform") == "XB": df.set_value(elem,␣
↪"Platform_XB", 1)
        if df.get_value(elem, "Platform") == "X360": df.set_value(elem,␣
↪"Platform_X360", 1)
        if df.get_value(elem, "Platform") == "XOne": df.set_value(elem,␣
↪"Platform_XOne", 1)
        if df.get_value(elem, "Platform") == "PS": df.set_value(elem,␣
↪"Platform_PS", 1)
        if df.get_value(elem, "Platform") == "PS2": df.set_value(elem,␣
↪"Platform_PS2", 1)
        if df.get_value(elem, "Platform") == "PS3": df.set_value(elem,␣
↪"Platform_PS3", 1)
        if df.get_value(elem, "Platform") == "PS4": df.set_value(elem,␣
↪"Platform_PS4", 1)
        if df.get_value(elem, "Platform") == "PSP": df.set_value(elem,␣
↪"Platform_PSP", 1)
        if df.get_value(elem, "Platform") == "PSV": df.set_value(elem,␣
↪"Platform_PSV", 1)
        if df.get_value(elem, "Platform") == "GB": df.set_value(elem,␣
↪"Platform_GB", 1)
        if df.get_value(elem, "Platform") == "GBA": df.set_value(elem,␣
↪"Platform_GBA", 1)
        if df.get_value(elem, "Platform") == "DS": df.set_value(elem,␣
↪"Platform_DS", 1)
```

```
        if df.get_value(elem, "Platform") == "3DS": df.set_value(elem,␣
↪"Platform_3DS", 1)
        if df.get_value(elem, "Platform") == "NES": df.set_value(elem,␣
↪"Platform_NES", 1)
        if df.get_value(elem, "Platform") == "SNES": df.set_value(elem,␣
↪"Platform_SNES", 1)
        if df.get_value(elem, "Platform") == "N64": df.set_value(elem,␣
↪"Platform_N64", 1)
        if df.get_value(elem, "Platform") == "GC": df.set_value(elem,␣
↪"Platform_GC", 1)
        if df.get_value(elem, "Platform") == "Wii": df.set_value(elem,␣
↪"Platform_Wii", 1)
        if df.get_value(elem, "Platform") == "WiiU": df.set_value(elem,␣
↪"Platform_WiiU", 1)

    # Discretizzazione feature Genre

    df["Genre_Action"] = 0
    df["Genre_Adventure"] = 0
    df["Genre_Fighting"] = 0
    df["Genre_Misc"] = 0
    df["Genre_Platform"] = 0
    df["Genre_Puzzle"] = 0
    df["Genre_Shooter"] = 0
    df["Genre_Sports"] = 0
    df["Genre_Simulation"] = 0
    df["Genre_Strategy"] = 0
    df["Genre_Racing"] = 0
    df["Genre_Role-Playing"] = 0

    for elem in df.index.get_values():
        if df.get_value(elem, "Genre") == "Action": df.set_value(elem,␣
↪"Genre_Action", 1)
        if df.get_value(elem, "Genre") == "Adventure": df.set_value(elem,␣
↪"Genre_Adventure", 1)
        if df.get_value(elem, "Genre") == "Fighting": df.set_value(elem,␣
↪"Genre_Fighting", 1)
        if df.get_value(elem, "Genre") == "Misc": df.set_value(elem,␣
↪"Genre_Misc", 1)
        if df.get_value(elem, "Genre") == "Platform": df.set_value(elem,␣
↪"Genre_Platform", 1)
        if df.get_value(elem, "Genre") == "Puzzle": df.set_value(elem,␣
↪"Genre_Puzzle", 1)
        if df.get_value(elem, "Genre") == "Shooter": df.set_value(elem,␣
↪"Genre_Shooter", 1)
```

```
        if df.get_value(elem, "Genre") == "Sports": df.set_value(elem,␣
↪"Genre_Sports", 1)
        if df.get_value(elem, "Genre") == "Simulation": df.set_value(elem,␣
↪"Genre_Simulation", 1)
        if df.get_value(elem, "Genre") == "Strategy": df.set_value(elem,␣
↪"Genre_Strategy", 1)
        if df.get_value(elem, "Genre") == "Racing": df.set_value(elem,␣
↪"Genre_Racing", 1)
        if df.get_value(elem, "Genre") == "Role-Playing": df.set_value(elem,␣
↪"Genre_Role-Playing", 1)


    df["Rating_Everyone"] = 0
    df["Rating_Everyone10"] = 0
    df["Rating_Teen"] = 0
    df["Rating_Mature"] = 0
    df["Rating_Adult"] = 0

    for elem in df.index.get_values():
        if df.get_value(elem, "Rating") == "E": df.set_value(elem,␣
↪"Rating_Everyone", 1)
        if df.get_value(elem, "Rating") == "E10+": df.set_value(elem,␣
↪"Rating_Everyone10", 1)
        if df.get_value(elem, "Rating") == "T": df.set_value(elem,␣
↪"Rating_Teen", 1)
        if df.get_value(elem, "Rating") == "M": df.set_value(elem,␣
↪"Rating_Mature", 1)
        if df.get_value(elem, "Rating") == "AO": df.set_value(elem,␣
↪"Rating_Adult", 1)

    # Discretizzazione feature Publisher

    publisher_list = []

    for elem in df.Publisher:
        if elem not in publisher_list:
            publisher_list.append(elem)

    for elem in publisher_list:
        df[elem] = 0

    for elem in df.index.get_values():
        df.set_value(elem, df.get_value(elem, "Publisher"), 1)

    # Discretizzazione feature Developer
```

```
developer_list = []

for elem in df.Developer:
    if elem not in developer_list:
        developer_list.append(elem)

for elem in developer_list:
    df[elem] = 0

for elem in df.index.get_values():
    df.set_value(elem, df.get_value(elem, "Developer"), 1)


df = df[df.Rating != 'AO']
df = df[df.Rating != 'K-A']
df = df[df.Rating != 'RP']
df = df[df.Rating != 'EC']


del df['User_Score']
del df['User_Count']
del df['Critic_Score']
del df['Critic_Count']

del df['Platform']
del df['Genre']
del df['Publisher']
del df['Developer']


del df['Rating_Adult']

df = df.reindex(np.random.permutation(df.index)).reset_index(drop=True)

y_true = np.array(df['Rating'])
vector_names = np.array(df['Name'])
del df['Name']

y_true_int = np.empty(len(y_true), dtype=int)
i = 0
for elem in y_true:
    if elem == "E":
        y_true_int[i] = 1
    elif elem == "E10+":
        y_true_int[i] = 2
    elif elem == "T":
        y_true_int[i] = 3
```

```
        else:
            y_true_int[i] = 4
        i += 1

    del df['Rating']

    df = df.astype('float64')

    print(" Dataset Analysis  ")

    print_e = df["Rating_Everyone"].value_counts()[1]
    print_e10 = df["Rating_Everyone10"].value_counts()[1]
    print_teen = df["Rating_Teen"].value_counts()[1]
    print_mature = df["Rating_Mature"].value_counts()[1]

    print("Number of elements: " + str(print_e + print_e10 + print_teen +␣
↪print_mature) + "\n")

    df_stampa = pd.DataFrame({"Rating": ['Everyone', 'Everyone 10+', 'Teen',␣
↪'Mature'],
                              "Counts": [print_e, print_e10, print_teen,␣
↪print_mature]})

    cols = df_stampa.columns.tolist()
    cols = cols[-1:] + cols[:-1]
    df_stampa = df_stampa[cols]

    print(df_stampa)
```

```
 Dataset Analysis
Number of elements: 6808

   Counts        Rating
0    2079      Everyone
1     930  Everyone 10+
2    2367          Teen
3    1432        Mature
```

Utility Function for plot_learning_curve.

[207]:
```
def plot_learning_curve(estimator, title, X, y, ylim=None, cv=None, n_jobs=1,␣
↪train_sizes=np.linspace(.1, 1.0, 5)):
    plt.figure()
    plt.title(title)
    if ylim is not None:
        plt.ylim(*ylim)
    plt.xlabel("Training examples")
```

```
    plt.ylabel("Score")
    train_sizes, train_scores, test_scores = learning_curve(estimator, X, y,␣
 ↪cv=cv, n_jobs=n_jobs,
                                                                         ␣
 ↪train_sizes=train_sizes)
    train_scores_mean = np.mean(train_scores, axis=1)
    train_scores_std = np.std(train_scores, axis=1)
    test_scores_mean = np.mean(test_scores, axis=1)
    test_scores_std = np.std(test_scores, axis=1)
    plt.grid()

    plt.fill_between(train_sizes, train_scores_mean - train_scores_std,
                     train_scores_mean + train_scores_std, alpha=0.1,
                     color="r")
    plt.fill_between(train_sizes, test_scores_mean - test_scores_std,
                     test_scores_mean + test_scores_std, alpha=0.1, color="g")
    plt.plot(train_sizes, train_scores_mean, 'o-', color="r",
             label="train_scores_mean")
    plt.plot(train_sizes, test_scores_mean, 'o-', color="g",
             label="Test_scores_mean")

    plt.legend(loc="best")
    return plt
```

[208]:
```
### 3. Third ML Problem
#### X=> Year_of_Release Sales Platform
#### y=> RATING EVERYONE
```

[209]:
```
#### Random Forest
```

[210]:
```
    from sklearn.model_selection import learning_curve
    import pandas as pd
    import numpy as np
    import seaborn as sns

    from sklearn.neighbors import KNeighborsClassifier
    from sklearn.model_selection import train_test_split
    from sklearn.metrics import accuracy_score
    from sklearn.model_selection import cross_val_score
    from sklearn.linear_model import LogisticRegression
    from sklearn.ensemble import RandomForestClassifier
    from sklearn.ensemble import VotingClassifier

    from sklearn.model_selection import learning_curve
    import matplotlib.pyplot as plt

    print("RATING EVERYONE")
```

```
df2 = df
y = df2['Rating_Everyone'].values
df2 = df2.drop(['Rating_Everyone'], axis=1)
df2 = df2.drop(['Rating_Everyone10'], axis=1)
df2 = df2.drop(['Rating_Teen'], axis=1)
df2 = df2.drop(['Rating_Mature'], axis=1)
X = df2.values


Xtrain, Xtest, ytrain, ytest = train_test_split(X, y, test_size=0.20)


print("Random Forest: ")
plot_learning_curve(RandomForestClassifier(), "Rating_Everyone Learning␣
↪Curves (Random Forest)", X, y,
                        n_jobs=-1)
```

```
RATING EVERYONE
Random Forest:
```

[210]:
```
<module 'matplotlib.pyplot' from
'/Users/nselvarajan/anaconda3/lib/python3.7/site-packages/matplotlib/pyplot.py'>
```

k-NN

[211]:
```
print("k-NN: ")
plot_learning_curve(KNeighborsClassifier(), "Rating_Everyone Learning Curves␣
↪(k-NN)", X, y, n_jobs=-1)
```

```
k-NN:
```

[211]: <module 'matplotlib.pyplot' from
'/Users/nselvarajan/anaconda3/lib/python3.7/site-packages/matplotlib/pyplot.py'>

LogisticRegression

[232]:
```
log_reg1 = LogisticRegression(penalty='l1', dual=False, C=1.0, fit_intercept=True, intercept_scaling=1,
                               class_weight=None, random_state=None, solver='liblinear', max_iter=100,
                               multi_class='ovr', verbose=0, warm_start=False, n_jobs=1)
log_reg1.fit(Xtrain, ytrain)
y_val_l = log_reg1.predict(Xtest)
ris = accuracy_score(ytest, y_val_l)
mis = accuracy_score(ytest, y_val_l, normalize=False)

print("Logistic Regression Rating_Everyone accuracy: ", ris)
print("Logistic Regression Rating_Everyone misclassification: ", ytest.size - mis)
MAE_rf = mean_absolute_error(ytest, y_val_l)
MSE_rf = mean_squared_error(ytest, y_val_l)
print("mae for Logistic Regression: " + str(MAE_rf))
print("mse for Logistic Regression: " + str(MSE_rf))
print("accuracy for Logistic Regression:" + str(log_reg1.score(Xtest,y_val_l)))
print("variance for Logistic Regression :" + str(explained_variance_score(ytest, y_val_l)))
```

```
Logistic Regression Rating_Everyone accuracy:  0.8333750939614132
Logistic Regression Rating_Everyone misclassification:  665
mae for Logistic Regression: 0.16662490603858682
mse for Logistic Regression: 0.16662490603858682
```

```
accuracy for Logistic Regression:0.8333750939614132
variance for Logistic Regression :0.011810211222773925
```

RandomForestClassifier

```
[233]:   radm1 = RandomForestClassifier(n_estimators=240, criterion='gini',␣
↪max_depth=None, min_samples_split=2,
                                 min_samples_leaf=1,
                                 min_weight_fraction_leaf=0.0,␣
↪max_features='auto', max_leaf_nodes=None,
                                 min_impurity_split=1e-07, bootstrap=True,
                                 oob_score=True, n_jobs=1, random_state=None,␣
↪verbose=0, warm_start=False,
                                 class_weight=None)
   radm1.fit(Xtrain, ytrain)
   y_val_l = radm1.predict(Xtest)
   ris = accuracy_score(ytest, y_val_l)
   mis = accuracy_score(ytest, y_val_l, normalize=False)
   print("Random Forest Rating_Everyone accuracy: ", ris)
   print("Random Forest Rating_Everyone misclassification: ", ytest.size - mis)
   MAE_rf = mean_absolute_error(ytest, y_val_l)
   MSE_rf = mean_squared_error(ytest, y_val_l)
   print("mae for RandomForestClassifier: " + str(MAE_rf))
   print("mse for RandomForestClassifier: " + str(MSE_rf))
   print("accuracy for RandomForestClassifier:" + str(radm1.
↪score(Xtest,ytest)))
   print("variance for RandomForestClassifier :" +␣
↪str(explained_variance_score(ytest, y_val_l)))
```

```
Random Forest Rating_Everyone accuracy:  0.8153345026309196
Random Forest Rating_Everyone misclassification:  737
mae for RandomForestClassifier: 0.18466549736908044
mse for RandomForestClassifier: 0.18466549736908044
accuracy for RandomForestClassifier:0.8153345026309196
variance for RandomForestClassifier :-0.24269676733883894
```

KNeighborsClassifier

```
[237]:   knn1 = KNeighborsClassifier(n_neighbors=10, weights='uniform',␣
↪algorithm='auto', leaf_size=30, p=1,
                             metric='minkowski', metric_params=None,␣
↪n_jobs=1)
   knn1.fit(Xtrain, ytrain)
   y_val_l = knn1.predict(Xtest)
   ris = accuracy_score(ytest, y_val_l)
   mis = accuracy_score(ytest, y_val_l, normalize=False)
   print("K-Nearest Neighbors Rating_Everyone accuracy: ", ris)
```

```
    print("K-Nearest Neighbors Rating_Everyone misclassification: ", ytest.size␣
↪- mis)
    print("K-Nearest Neighbors Rating_Everyone accuracy: ", ris)
    print("K-Nearest Neighbors Rating_Everyone misclassification: ", ytest.size␣
↪- mis)
    MAE_rf = mean_absolute_error(ytest, y_val_l)
    MSE_rf = mean_squared_error(ytest, y_val_l)
    print("mae for K-Nearest Neighbors: " + str(MAE_rf))
    print("mse for K-Nearest Neighbors: " + str(MSE_rf))
    print("accuracy for K-Nearest Neighbors:" + str(ris))
    print("variance for K-Nearest Neighbors :" +␣
↪str(explained_variance_score(ytest, y_val_l)))

    print("\n")
```

```
K-Nearest Neighbors Rating_Everyone accuracy:  0.8376346780255575
K-Nearest Neighbors Rating_Everyone misclassification:  648
K-Nearest Neighbors Rating_Everyone accuracy:  0.8376346780255575
K-Nearest Neighbors Rating_Everyone misclassification:  648
mae for K-Nearest Neighbors: 0.1623653219744425
mse for K-Nearest Neighbors: 0.1623653219744425
accuracy for K-Nearest Neighbors:0.8376346780255575
variance for K-Nearest Neighbors :-0.03927400129078129
```

Evaluate Different Models

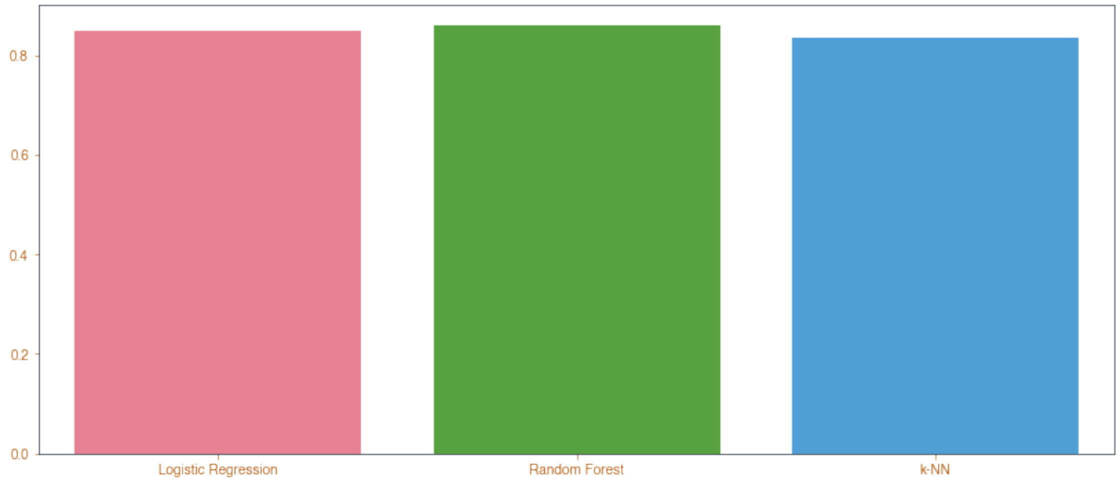
[215]:
```
    for clf, label in zip([log_reg1, radm1, knn1], ['Logistic Regression',␣
↪'Random Forest', 'k-NN']):
        scores = cross_val_score(clf, X, y, cv=5, scoring='accuracy')
        print("Accuracy Score: %0.5f [%s]" % (scores.mean(), label))
```

```
Accuracy Score: 0.85165 [Logistic Regression]
Accuracy Score: 0.85899 [Random Forest]
Accuracy Score: 0.83681 [k-NN]
```

2.2 Comparison of Accuracy of the models

[216]:
```
# # Comparison of Accuracy of the models
MSEs = [0.84768,0.85913,0.83519]

models = ['Logistic Regression','Random Forest','k-NN']
plt.figure(figsize=(14,6))
sns.barplot(models,MSEs,palette='husl')
```

[216]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a208b35f8>
```


0.8
0.6
0.4
0.2
0.0
Logistic Regression
Random Forest
k-NN

[ ]:

[ ]:

[ ]: