On the track of the most important movie feature

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Objective

The aim of our project was to create a model that predicts the movie genres based on other features, such as keywords, title, budget etc.

Dataset

Description

We used a dataset from Kaggle (https://www.kaggle.com/rounakbanik/the-movies-dataset). It contains metadata for 45 000 movies. There are many different features in the dataset - we were interested in the 'genres', 'budget', 'production_companies', 'production_countries', 'revenue', 'title', 'cast', 'director' and 'keywords'. Each movie can have multiple genres.

Data

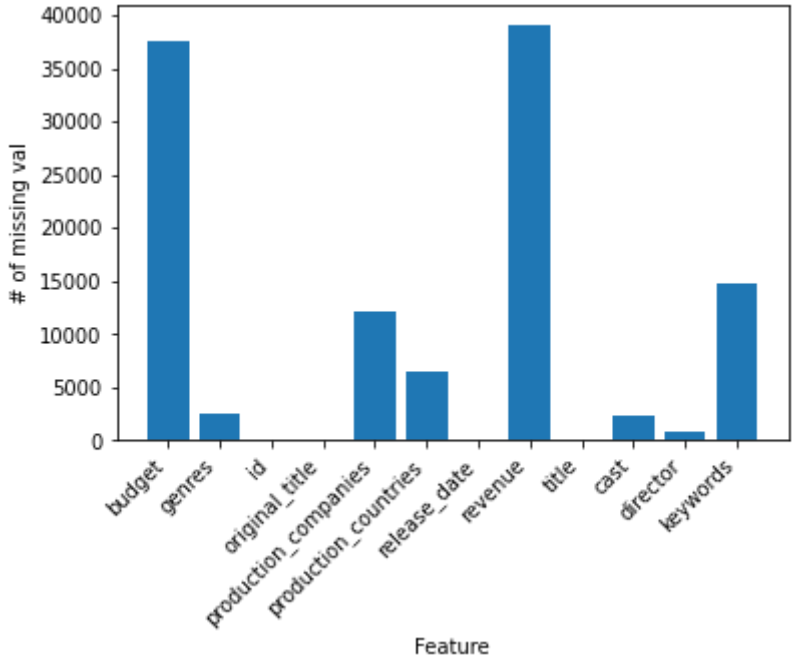
It turned out that many samples had missing values, e.g. there were 14818 samples with empty keywords list or 12199 with no production companies. The columns 'budget' and 'revenue' were set to 0 over 3700 times - this is most of the dataset. There were a few rows with data of incorrect type, such as strings in the column 'budget', which we dropped. The genres were not balanced - the most popular, 'Drama' occured over 20000 times, and the least popular - TV Movie - only around 1000 times.

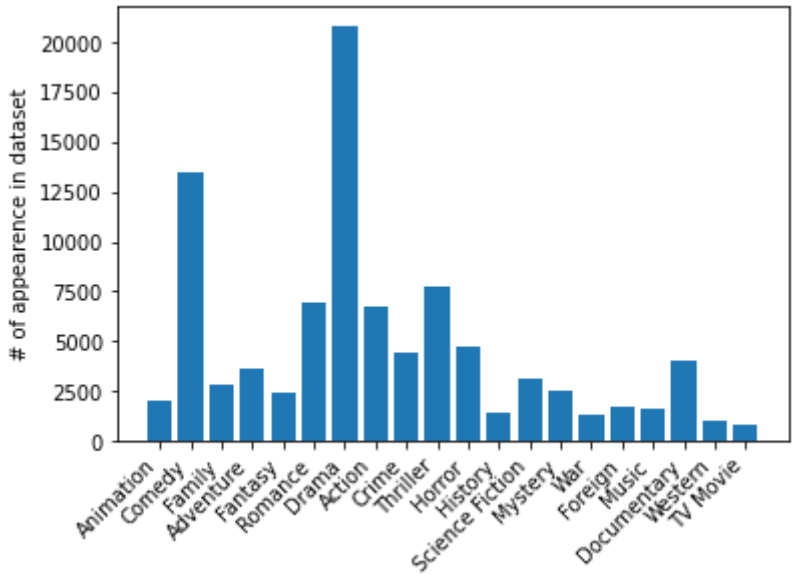
The figures showing detailed statistics and the most common combinations of genres are presented below.

In [1]:
```
%run data_prep.ipynb
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\p
andas\core\indexing.py:1732: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-do
cs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self._setitem_single_block(indexer, value, name)
```






```
Animation :  [(878, 'Family'), (564, 'Comedy')]
Comedy :  [(4295, 'Drama'), (3197, 'Romance')]
Family :  [(1205, 'Comedy'), (878, 'Animation')]
Adventure :  [(1775, 'Action'), (1071, 'Drama')]
Fantasy :  [(744, 'Comedy'), (712, 'Drama')]
Romance :  [(4605, 'Drama'), (3197, 'Comedy')]
Drama :  [(4605, 'Romance'), (4295, 'Comedy')]
Action :  [(2395, 'Thriller'), (2368, 'Drama')]
Crime :  [(2581, 'Drama'), (2055, 'Thriller')]
Thriller :  [(3491, 'Drama'), (2395, 'Action')]
Horror :  [(1951, 'Thriller'), (890, 'Science Fiction')]
History :  [(1098, 'Drama'), (346, 'War')]
Science Fiction :  [(1101, 'Action'), (890, 'Horror')]
Mystery :  [(1535, 'Thriller'), (1201, 'Drama')]
War :  [(1006, 'Drama'), (346, 'History')]
Foreign :  [(1009, 'Drama'), (408, 'Comedy')]
Music :  [(645, 'Drama'), (578, 'Comedy')]
Documentary :  [(348, 'Music'), (216, 'Drama')]
Western :  [(371, 'Action'), (277, 'Drama')]
TV Movie :  [(406, 'Drama'), (174, 'Comedy')]
```

Multi label and text features

Many of the columns were text, multi-label or both. We tried two distinct solutions for representing them.

First, we represented multi-label columns as binary matrixes - each column represented one label and was set to 1 if the sample contained this label. This is the standard representation in sklearn. The features could have many unique labels - e.g. there were 18186 different keywords. We used only the popular labels, e.g. keywords that occured at least 20 times, and discarded the rest.

However, this solution could not work for the text values that are unique for each row, such as the titles. Therefore we tried another solution - we used a pre-trained (Wikipedia 2014 + Gigaword) Word2Vec model. We took the average of the vectors for each word in the value.

Handling missing values

We used two different solutions for handling the missing data. First, we simply treated them as normal values. Second, we tried imputing them using IterativeImputer from sklearn.

Survey

In order to gauge the difficulty of the task we created a small survey. We selected 11 movies from the dataset and asked the participants to guess the genres based on the title and keywords. There were 15 responses. We calculated the averge precision to be 0.382 and and the average recall to be 0.421.

Models

We used three different combinations of the data:\ (1) Only numeric columns: 'budget' and 'revenue'\ (2) Columns 'keywords' and 'production_countries', limited to the most popular labels and processed by MultiLabelBinarizer + 'budget', 'revenue'\ (3) Columns 'keywords' and 'titles' transformed by Word2Vec and avereged + 'production_companies_cols', 'production_countries_cols', 'cast' limited to the most popular and processed by MultiLabelBinarizer + 'budget', 'revenue'

We used three different models: logistic regression, random forest and XGBoost.

In order to score the performance of the model, we use classification_report from sklearn. It calculates precision, recall and the F1 score.

Logistic regression

The logistic regression did not perform well. For the data (2) it gave the following results:

	Precision	Recall	F1 Score
micro avg	0.111	0.017	0.030
macro avg	0.033	0.017	0.020
weighted avg	0.058	0.017	0.024
samples avg	0.006	0.015	0.008

Random forest

The random forest was much better. It performed best for the data (2):

	Precision	Recall	F1 Score
micro avg	0.601	0.260	0.363
macro avg	0.546	0.189	0.273
weighted avg	0.576	0.260	0.346
samples avg	0.360	0.263	0.284

XGBoost

The best results in this project were achieved using this model and the data (3):

	Precision	Recall	F1 Score
micro avg	0.670	0.351	0.461
macro avg	0.683	0.257	0.356
weighted avg	0.666	0.351	0.440
samples avg	0.503	0.384	0.406

Order of imputation

All results for different combinations of the data and models can be found in the code section.

Code

Below is the full code for our project along the outputs.

In [28]:
```
import pandas as pd
import ast
import matplotlib.pyplot as plt
from collections import defaultdict as dd
```

In [4]:
```
# Data from https://www.kaggle.com/rounakbanik/the-movies-dataset
movies_cols = ['genres', 'id', 'budget', 'original_title', 'production_c
               'release_date', 'revenue', 'title']
movies_df = pd.read_csv("movies_metadata.csv.zip", usecols=movies_cols).
credits_df = pd.read_csv("credits.csv.zip")
keywords_df = pd.read_csv("keywords.csv.zip")
```

In [5]:
```
movies_df.head()
```

Out[5]:

	budget	genres	id	original_title	production_companies	production_countries	r
0	30000000	[{'id': 16, 'name': 'Animation'}, {'id': 35, '...	862	Toy Story	[{'name': 'Pixar Animation Studios', 'id': 3}]	[{'iso_3166_1': 'US', 'name': 'United States o...	
1	65000000	[{'id': 12, 'name': 'Adventure'}, {'id': 14, '...	8844	Jumanji	[{'name': 'TriStar Pictures', 'id': 559}, {'na...	[{'iso_3166_1': 'US', 'name': 'United States o...	
2	0	[{'id': 10749, 'name': 'Romance'}, {'id': 35, ...	15602	Grumpier Old Men	[{'name': 'Warner Bros.', 'id': 6194}, {'name'...	[{'iso_3166_1': 'US', 'name': 'United States o...	
3	16000000	[{'id': 35, 'name': 'Comedy'}, {'id': 18, 'nam...	31357	Waiting to Exhale	[{'name': 'Twentieth Century Fox Film Corporat...	[{'iso_3166_1': 'US', 'name': 'United States o...	
4	0	[{'id': 35, 'name': 'Comedy'}]	11862	Father of the Bride Part II	[{'name': 'Sandollar Productions', 'id': 5842}...	[{'iso_3166_1': 'US', 'name': 'United States o...	

In [6]:
```
credits_df.head()
```

Out[6]:

	cast	crew	id
0	[{'cast_id': 14, 'character': 'Woody (voice)',...	[{'credit_id': '52fe4284c3a36847f8024f49', 'de...	862
1	[{'cast_id': 1, 'character': 'Alan Parrish', '...	[{'credit_id': '52fe44bfc3a36847f80a7cd1', 'de...	8844
2	[{'cast_id': 2, 'character': 'Max Goldman', 'c...	[{'credit_id': '52fe466a9251416c75077a89', 'de...	15602
3	[{'cast_id': 1, 'character': "Savannah 'Vannah...	[{'credit_id': '52fe44779251416c91011acb', 'de...	31357
4	[{'cast_id': 1, 'character': 'George Banks', '...	[{'credit_id': '52fe44959251416c75039ed7', 'de...	11862

In [7]:
```
keywords_df.head()
```

Out[7]:

	id	keywords
0	862	[{'id': 931, 'name': 'jealousy'}, {'id': 4290,...
1	8844	[{'id': 10090, 'name': 'board game'}, {'id': 1...
2	15602	[{'id': 1495, 'name': 'fishing'}, {'id': 12392...
3	31357	[{'id': 818, 'name': 'based on novel'}, {'id':...
4	11862	[{'id': 1009, 'name': 'baby'}, {'id': 1599, 'n...

In [8]:
```
def resolve_jsons(df, column_name, ):
    i = 0
    for col in df[column_name]:
        new_col = []
        try:
            col = ast.literal_eval(col)
            for c in col:
                new_col.append(c["name"])
            df[column_name].iloc[i] = new_col
        except (ValueError,TypeError):
            pass
        i+=1
```

In [9]:
```
resolve_jsons(movies_df, 'genres' )
resolve_jsons(movies_df, 'production_companies')
resolve_jsons(movies_df, 'production_countries')
resolve_jsons(keywords_df, 'keywords')
resolve_jsons(credits_df,'cast')
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\p
andas\core\indexing.py:1732: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-do
cs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self._setitem_single_block(indexer, value, name)
```

In [10]:
```
#isolated director from crew property and repleced the column 'crew' for
i = 0
for col in credits_df["crew"]:
    new_col = []
    try:
            col = ast.literal_eval(col)
            for c in col:
                if c["job"] == "Director":
                    new_col.append(c["name"])
            credits_df["crew"].iloc[i] = new_col
    except (ValueError,TypeError):
        pass
    i+=1
credits_df = credits_df.rename(columns={"crew":"director"})
```

In [11]:
```
credits_df.head()
```

Out[11]:

	cast	director	id
0	[Tom Hanks, Tim Allen, Don Rickles, Jim Varney...	[John Lasseter]	862
1	[Robin Williams, Jonathan Hyde, Kirsten Dunst,...	[Joe Johnston]	8844
2	[Walter Matthau, Jack Lemmon, Ann-Margret, Sop...	[Howard Deutch]	15602
3	[Whitney Houston, Angela Bassett, Loretta Devi...	[Forest Whitaker]	31357
4	[Steve Martin, Diane Keaton, Martin Short, Kim...	[Charles Shyer]	11862

In [12]:
```
#merging credits,movies,keywords df into one table
credits_df = credits_df.merge(keywords_df,how='right',on='id')
```

In [13]:
```
credits_df.head()
```

Out[13]:

	cast	director	id	keywords
0	[Tom Hanks, Tim Allen, Don Rickles, Jim Varney...	[John Lasseter]	862	[jealousy, toy, boy, friendship, friends, riva...
1	[Robin Williams, Jonathan Hyde, Kirsten Dunst,...	[Joe Johnston]	8844	[board game, disappearance, based on children'...
2	[Walter Matthau, Jack Lemmon, Ann-Margret, Sop...	[Howard Deutch]	15602	[fishing, best friend, duringcreditsstinger, o...
3	[Whitney Houston, Angela Bassett, Loretta Devi...	[Forest Whitaker]	31357	[based on novel, interracial relationship, sin...
4	[Steve Martin, Diane Keaton, Martin Short, Kim...	[Charles Shyer]	11862	[baby, midlife crisis, confidence, aging, daug...

In [14]:
```
movies_df['id']=movies_df['id'].astype(int).astype("int64")

movies_df = movies_df.merge(credits_df)
```

In [15]:
```
# Some columns have values of bad type, for example strings in 'budget'.
movies_df['budget'] = pd.to_numeric(movies_df['budget'], errors='coerce'
movies_df['revenue'] = pd.to_numeric(movies_df['revenue'], errors='coerc
movies_df = movies_df.dropna()
```

In [16]:
```
movies_df.head(10)
```

Out[16]:

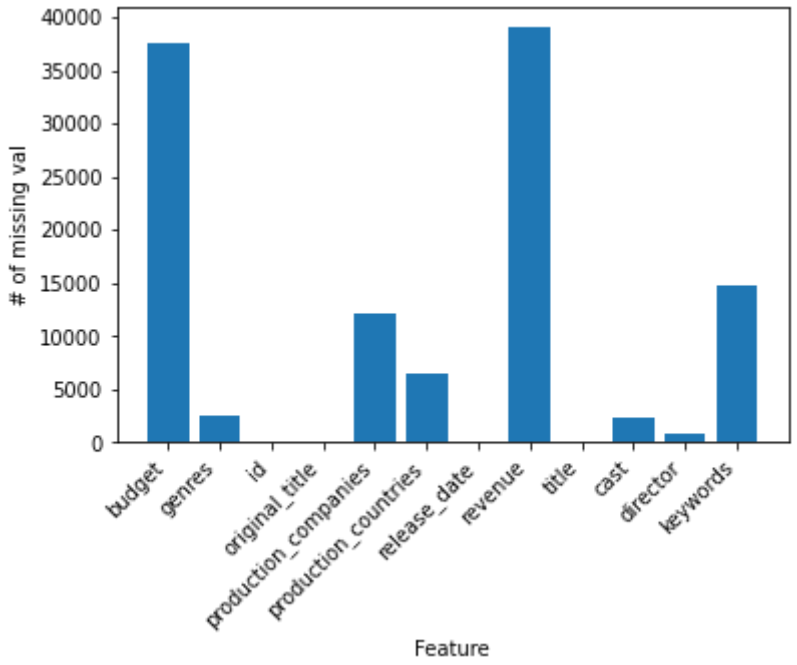
	budget	genres	id	original_title	production_companies	production_countries	re
0	30000000	[Animation, Comedy, Family]	862	Toy Story	[Pixar Animation Studios]	[United States of America]	
1	65000000	[Adventure, Fantasy, Family]	8844	Jumanji	[TriStar Pictures, Teitler Film, Interscope Co...	[United States of America]	
2	0	[Romance, Comedy]	15602	Grumpier Old Men	[Warner Bros., Lancaster Gate]	[United States of America]	
3	16000000	[Comedy, Drama, Romance]	31357	Waiting to Exhale	[Twentieth Century Fox Film Corporation]	[United States of America]	
4	0	[Comedy]	11862	Father of the Bride Part II	[Sandollar Productions, Touchstone Pictures]	[United States of America]	
5	60000000	[Action, Crime, Drama, Thriller]	949	Heat	[Regency Enterprises, Forward Pass, Warner Bros.]	[United States of America]	
6	58000000	[Comedy, Romance]	11860	Sabrina	[Paramount Pictures, Scott Rudin Productions, ...	[Germany, United States of America]	
7	0	[Action, Adventure, Drama, Family]	45325	Tom and Huck	[Walt Disney Pictures]	[United States of America]	
8	35000000	[Action, Adventure, Thriller]	9091	Sudden Death	[Universal Pictures, Imperial Entertainment, S...	[United States of America]	

	budget	genres	id	original_title	production_companies	production_countries	re
9	58000000	[Adventure, Action, Thriller]	710	GoldenEye	[United Artists, Eon Productions]	[United Kingdom, United States of America]	

In [26]:

```
#data statistics
sum_missing_val = []
for col in movies_df.columns:
    sum = 0
    for x in movies_df[col]:
        if x == [] or x == 0 or x == None:
            sum += 1
    sum_missing_val.append(sum)

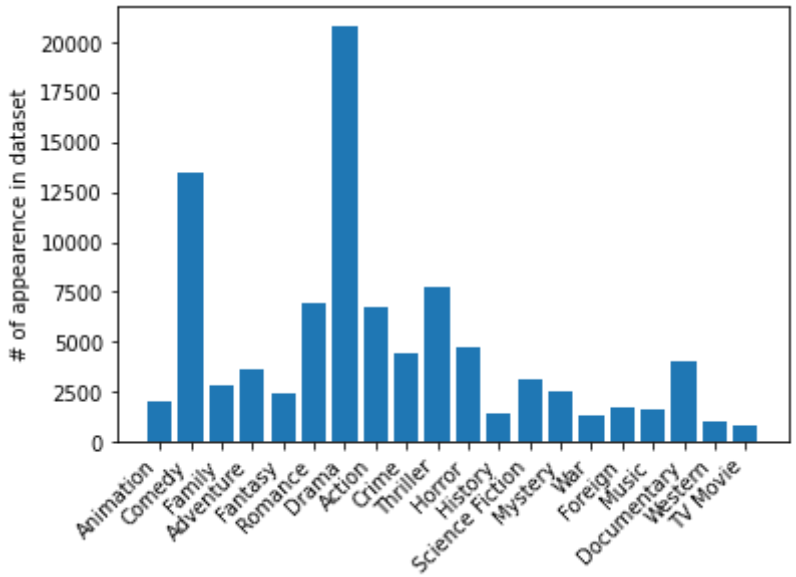

x = movies_df.columns
num_col = len(x)
y = sum_missing_val
plt.bar(x,y)
plt.xlabel('Feature')
plt.ylabel('# of missing val')
plt.xticks(rotation=45, ha="right")
plt.show()
```



In [36]:

```
genres = dd(int)
for x in movies_df['genres']:
    for genre in x:
        genres[genre] += 1

genres_names = genres.keys()
num_genres = len(genres_names)
y = genres.values()
plt.bar(genres_names,y)
plt.ylabel('# of appearence in dataset')
plt.xticks(rotation=45, ha="right")
plt.show()
```



In [56]:

```
# which genres appear with others the most

genres = [dd(int) for x in genres_names]
for x in movies_df['genres']:
    for genre1 in x:
        for genre2 in x:
            genres[list(genres_names).index(genre1)][genre2] +=1

for genre in list(genres_names):

    most_common_pair_genre = genres[list(genres_names).index(genre)].key
    most_common_pair_count = genres[list(genres_names).index(genre)].val
    most_common_pairs = list(zip(most_common_pair_count,most_common_pair
    most_common_pairs = sorted(most_common_pairs,reverse=True)
    most_common_pairs = most_common_pairs[1:3]
    print(genre,": ", most_common_pairs)
```

```
Animation :  [(878, 'Family'), (564, 'Comedy')]
Comedy :  [(4295, 'Drama'), (3197, 'Romance')]
Family :  [(1205, 'Comedy'), (878, 'Animation')]
Adventure :  [(1775, 'Action'), (1071, 'Drama')]
Fantasy :  [(744, 'Comedy'), (712, 'Drama')]
Romance :  [(4605, 'Drama'), (3197, 'Comedy')]
Drama :  [(4605, 'Romance'), (4295, 'Comedy')]
Action :  [(2395, 'Thriller'), (2368, 'Drama')]
Crime :  [(2581, 'Drama'), (2055, 'Thriller')]
Thriller :  [(3491, 'Drama'), (2395, 'Action')]
Horror :  [(1951, 'Thriller'), (890, 'Science Fiction')]
History :  [(1098, 'Drama'), (346, 'War')]
Science Fiction :  [(1101, 'Action'), (890, 'Horror')]
Mystery :  [(1535, 'Thriller'), (1201, 'Drama')]
War :  [(1006, 'Drama'), (346, 'History')]
Foreign :  [(1009, 'Drama'), (408, 'Comedy')]
Music :  [(645, 'Drama'), (578, 'Comedy')]
Documentary :  [(348, 'Music'), (216, 'Drama')]
Western :  [(371, 'Action'), (277, 'Drama')]
TV Movie :  [(406, 'Drama'), (174, 'Comedy')]
```

In [2]:

```
original_movies_df = movies_df.copy() # Useful to go back to the origina
movies_df.head()
```

Out[2]:

	budget	genres	id	original_title	production_companies	production_countries	r
0	30000000	[Animation, Comedy, Family]	862	Toy Story	[Pixar Animation Studios]	[United States of America]	
1	65000000	[Adventure, Fantasy, Family]	8844	Jumanji	[TriStar Pictures, Teitler Film, Interscope Co...	[United States of America]	
2	0	[Romance, Comedy]	15602	Grumpier Old Men	[Warner Bros., Lancaster Gate]	[United States of America]	
3	16000000	[Comedy, Drama, Romance]	31357	Waiting to Exhale	[Twentieth Century Fox Film Corporation]	[United States of America]	
4	0	[Comedy]	11862	Father of the Bride Part II	[Sandollar Productions, Touchstone Pictures]	[United States of America]	

In [3]:

```
from sklearn.multioutput import MultiOutputClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import MultiLabelBinarizer
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, classification_report
from sklearn.experimental import enable_iterative_imputer
from sklearn.impute import IterativeImputer
import xgboost as xgb
import gensim.downloader
import numpy as np
```

In [4]:

```
# Replaces column col of lists of labels with a binary matrix.
# Returns new dataframe and new columns' names.
def binarize_column(df, col):
    mlb = MultiLabelBinarizer()
    return df.join(pd.DataFrame(mlb.fit_transform(df[col]), columns=mlb.
                   rsuffix="_suffix").drop(col, axis=1), list(mlb.classes

# Takes pandas Series with lists of labels as values.
# Returns a list of labels for which number of occurances > limit.
# Number of labels for 'keywords': > 0 : 18186, > 10 : 2193, > 20 : 1158
def popular_labels(series, limit):
    counts = {}
    for l in series:
        for v in l:
            counts[v] = counts.get(v, 0)+1
    return [k for k,v in counts.items() if v > limit]

# Takes pandas Series with lists of labels as values.
# Creates a new series with only labels that occur at least 'limit' time
def limit_labels(series, limit):
    new_series = series.copy()
    labels = popular_labels(series, limit)
    for i, l in series.iteritems():
        new_l = [val for val in l if val in labels]
        new_series[i] = new_l
    return new_series
```

In [5]:

```
# Transform categorical features into binary matrixes
movies_df['production_countries'] = limit_labels(movies_df['production_c
movies_df, _ = binarize_column(movies_df, 'production_countries')
movies_df['keywords'] = limit_labels(movies_df['keywords'], 20)
movies_df, _ = binarize_column(movies_df, 'keywords')

movies_df.head()
```

Out[5]:

	budget	genres	id	original_title	production_companies	release_date	reven
0	30000000	[Animation, Comedy, Family]	862	Toy Story	[Pixar Animation Studios]	1995-10-30	373554033
1	65000000	[Adventure, Fantasy, Family]	8844	Jumanji	[TriStar Pictures, Teitler Film, Interscope Co...	1995-12-15	262797249
2	0	[Romance, Comedy]	15602	Grumpier Old Men	[Warner Bros., Lancaster Gate]	1995-12-22	0
3	16000000	[Comedy, Drama, Romance]	31357	Waiting to Exhale	[Twentieth Century Fox Film Corporation]	1995-12-22	81452156
4	0	[Comedy]	11862	Father of the Bride Part II	[Sandollar Productions, Touchstone Pictures]	1995-02-10	76578911

5 rows × 1530 columns

In [6]:

```
#create list of possible genres
genres = []
for x in movies_df['genres']:
    for genre in x:
        if genre not in genres:
            genres.append(genre)
```

In [7]:

```
train_df, test_df = train_test_split(movies_df, test_size=0.2)

X_cols = ['budget', 'revenue'] # For now only numeric features
X_train = train_df[X_cols]
X_test = test_df[X_cols]

# We need to transform 'genres' since this is multi-label classification
mlb = MultiLabelBinarizer()

y_train = mlb.fit_transform(train_df['genres'])
y_test = mlb.fit_transform(test_df['genres'])
```

In [8]:

```
def random_forest(X_train,y_train,X_test,y_test):
    rfc = RandomForestClassifier()
    rfc.fit(X_train, y_train)
    y_pred = rfc.predict(X_test)
    return classification_report(y_test ,y_pred,target_names=genres, outp

def xgboost(X_train,y_train,X_test,y_test):
    xgbc = MultiOutputClassifier(xgb.XGBClassifier(verbosity = 0))
    xgbc.fit(X_train, y_train)
    y_pred = xgbc.predict(X_test)
    return classification_report(y_test ,y_pred,target_names=genres, outp

def logistic_reg(X_train, y_train,X_test,y_test):
    clf = MultiOutputClassifier(LogisticRegression()).fit(X_train, y_tra
    y_pred = clf.predict(X_test)
    return classification_report(y_test ,y_pred,target_names=genres, outp
```

In [9]:

```
# Random forest, only numeric columns

random_forest(X_train, y_train,X_test,y_test)
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Recall an
d F-score are ill-defined and being set to 0.0 in samples with no true la
bels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[9]:

```
{'Animation': {'precision': 0.32171581769436997,
  'recall': 0.09230769230769231,
  'f1-score': 0.1434548714883443,
  'support': 1300},
 'Comedy': {'precision': 0.3448275862068966,
  'recall': 0.09722222222222222,
  'f1-score': 0.1516793066088841,
  'support': 720},
 'Family': {'precision': 0.13636363636363635,
  'recall': 0.01485148514851485,
  'f1-score': 0.02678571428571428,
  'support': 404},
 'Adventure': {'precision': 0.3697632058287796,
  'recall': 0.07645951035781544,
  'f1-score': 0.12671660424469414,
  'support': 2655},
 'Fantasy': {'precision': 0.17801047120418848,
  'recall': 0.03711790393013101,
  'f1-score': 0.06142728093947606,
  'support': 916},
 'Romance': {'precision': 0.14285714285714285,
  'recall': 0.007537688442211055,
  'f1-score': 0.014319809069212411,
  'support': 796},
 'Drama': {'precision': 0.5537848605577689,
  'recall': 0.13384689455946075,
  'f1-score': 0.2155874369910818,
  'support': 4154},
 'Action': {'precision': 0.2222222222222222,
  'recall': 0.03103448275862069,
  'f1-score': 0.05446293494704992,
  'support': 580},
 'Crime': {'precision': 0.19540229885057472,
  'recall': 0.03736263736263736,
  'f1-score': 0.06273062730627306,
  'support': 455},
 'Thriller': {'precision': 0.15789473684210525,
  'recall': 0.009174311926605505,
  'f1-score': 0.017341040462427747,
  'support': 327},
 'Horror': {'precision': 0.22857142857142856,
  'recall': 0.02877697841726619,
  'f1-score': 0.051118210862619806,
  'support': 278},
 'History': {'precision': 0.22627737226277372,
  'recall': 0.033155080213903745,
  'f1-score': 0.057835820895522395,
  'support': 935},
 'Science Fiction': {'precision': 0.08823529411764706,
  'recall': 0.008823529411764706,
  'f1-score': 0.0160427807486631,
  'support': 340},
 'Mystery': {'precision': 0.0641025641025641,
  'recall': 0.0102880658436214,
  'f1-score': 0.01773049645390071,
  'support': 486},
 'War': {'precision': 0.23293172690763053,
  'recall': 0.041105598866052445,
  'f1-score': 0.06987951807228915,
  'support': 1411},
 'Foreign': {'precision': 0.1523809523809524,
  'recall': 0.02622950819672131,
  'f1-score': 0.04475524475524475,
```

```
  'support': 610},
 'Music': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 1
64},
 'Documentary': {'precision': 0.2558746736292428,
  'recall': 0.0625,
  'f1-score': 0.10046130189646335,
  'support': 1568},
 'Western': {'precision': 0.23809523809523808,
  'recall': 0.01858736059479554,
  'f1-score': 0.034482758620689655,
  'support': 269},
 'TV Movie': {'precision': 0.08333333333333333,
  'recall': 0.0044444444444444444,
  'f1-score': 0.008438818565400843,
  'support': 225},
 'micro avg': {'precision': 0.34484649122807015,
  'recall': 0.06765987199483676,
  'f1-score': 0.11312440987365677,
  'support': 18593},
 'macro avg': {'precision': 0.20963222810142473,
  'recall': 0.03854126975022405,
  'f1-score': 0.06376252886069758,
  'support': 18593},
 'weighted avg': {'precision': 0.31150624153311707,
  'recall': 0.06765987199483676,
  'f1-score': 0.11019897885702132,
  'support': 18593},
 'samples avg': {'precision': 0.0739740008594757,
  'recall': 0.0581297194425686,
  'f1-score': 0.05943915643636313,
  'support': 18593}}
```

In [10]:

```
# Logistic regression, only numeric columns
logistic_reg(X_train, y_train,X_test,y_test)
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in labels with no predic
ted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Recall an
d F-score are ill-defined and being set to 0.0 in samples with no true la
bels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[10]:

```
{'Animation': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 1300},
 'Comedy': {'precision': 0.09836065573770492,
  'recall': 0.075,
  'f1-score': 0.08510638297872339,
  'support': 720},
 'Family': {'precision': 0.04241071428571429,
  'recall': 0.04702970297029703,
  'f1-score': 0.04460093896713615,
  'support': 404},
 'Adventure': {'precision': 0.33760683760683763,
  'recall': 0.05951035781544256,
  'f1-score': 0.10118475824527698,
  'support': 2655},
 'Fantasy': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
916},
 'Romance': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
796},
 'Drama': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 4
154},
 'Action': {'precision': 0.06016597510373444,
  'recall': 0.05,
  'f1-score': 0.054613935969868174,
  'support': 580},
 'Crime': {'precision': 0.060215053763440864,
  'recall': 0.06153846153846154,
  'f1-score': 0.060869565217391314,
  'support': 455},
 'Thriller': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 327},
 'Horror': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
278},
 'History': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
935},
 'Science Fiction': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 340},
 'Mystery': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
486},
 'War': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 141
1},
 'Foreign': {'precision': 0.0625,
  'recall': 0.04426229508196721,
  'f1-score': 0.051823416506717845,
  'support': 610},
 'Music': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 1
64},
 'Documentary': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 1568},
 'Western': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
269},
 'TV Movie': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 225},
 'micro avg': {'precision': 0.11075949367088607,
```

```
 'recall': 0.016941859839724627,
 'f1-score': 0.02938844054671829,
 'support': 18593},
'macro avg': {'precision': 0.0330629618248716,
 'recall': 0.016867040870308415,
 'f1-score': 0.019909949894255694,
 'support': 18593},
'weighted avg': {'precision': 0.058340174773907474,
 'recall': 0.016941859839724627,
 'f1-score': 0.02360699872716338,
 'support': 18593},
'samples avg': {'precision': 0.0064281621544191375,
 'recall': 0.014881463973642746,
 'f1-score': 0.008117270687103087,
 'support': 18593}}
```

In [11]:

```
X_cols_to_drop = ['genres', 'id', 'original_title', 'production_companie
                  'release_date', 'title', 'cast', 'director']
X_train = train_df.drop(columns=X_cols_to_drop, axis=1)
X_test = test_df.drop(columns=X_cols_to_drop, axis=1)
```

In [12]:

```
# Random forest with limited keywords and production_countries
random_forest(X_train,y_train,X_test,y_test)
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Recall an
d F-score are ill-defined and being set to 0.0 in samples with no true la
bels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[12]:

```
{'Animation': {'precision': 0.5884413309982487,
  'recall': 0.25846153846153846,
  'f1-score': 0.35916622127204706,
  'support': 1300},
 'Comedy': {'precision': 0.5869565217391305,
  'recall': 0.15,
  'f1-score': 0.23893805309734512,
  'support': 720},
 'Family': {'precision': 0.7064220183486238,
  'recall': 0.1905940594059406,
  'f1-score': 0.3001949317738792,
  'support': 404},
 'Adventure': {'precision': 0.5570739549839229,
  'recall': 0.26101694915254237,
  'f1-score': 0.355475763016158,
  'support': 2655},
 'Fantasy': {'precision': 0.4897260273972603,
  'recall': 0.15611353711790393,
  'f1-score': 0.23675496688741723,
  'support': 916},
 'Romance': {'precision': 0.5233160621761658,
  'recall': 0.12688442211055276,
  'f1-score': 0.20424671385237614,
  'support': 796},
 'Drama': {'precision': 0.653556211078335,
  'recall': 0.48001925854597977,
  'f1-score': 0.5535045107564192,
  'support': 4154},
 'Action': {'precision': 0.46099290780141844,
  'recall': 0.11206896551724138,
  'f1-score': 0.18030513176144242,
  'support': 580},
 'Crime': {'precision': 0.55,
  'recall': 0.12087912087912088,
  'f1-score': 0.19819819819819817,
  'support': 455},
 'Thriller': {'precision': 0.3409090909090909,
  'recall': 0.045871559633027525,
  'f1-score': 0.08086253369272238,
  'support': 327},
 'Horror': {'precision': 0.3684210526315789,
  'recall': 0.050359712230215826,
  'f1-score': 0.08860759493670885,
  'support': 278},
 'History': {'precision': 0.7518987341772152,
  'recall': 0.3176470588235294,
  'f1-score': 0.4466165413533834,
  'support': 935},
 'Science Fiction': {'precision': 0.5363636363636364,
  'recall': 0.17352941176470588,
  'f1-score': 0.2622222222222222,
  'support': 340},
 'Mystery': {'precision': 0.411214953271028,
  'recall': 0.09053497942386832,
  'f1-score': 0.14839797639123103,
  'support': 486},
 'War': {'precision': 0.48058252427184467,
  'recall': 0.1403260099220411,
  'f1-score': 0.21722435545803617,
  'support': 1411},
 'Foreign': {'precision': 0.7184873949579832,
  'recall': 0.28032786885245903,
  'f1-score': 0.4033018867924528,
```

```
 'support': 610},
'Music': {'precision': 0.32558139534883723,
 'recall': 0.08536585365853659,
 'f1-score': 0.1352657004830918,
 'support': 164},
'Documentary': {'precision': 0.5618556701030928,
 'recall': 0.20854591836734693,
 'f1-score': 0.3041860465116279,
 'support': 1568},
'Western': {'precision': 0.5555555555555556,
 'recall': 0.16728624535315986,
 'f1-score': 0.2571428571428572,
 'support': 269},
'TV Movie': {'precision': 0.75,
 'recall': 0.36,
 'f1-score': 0.48648648648648657,
 'support': 225},
'micro avg': {'precision': 0.6013925152306353,
 'recall': 0.26015166998332706,
 'f1-score': 0.36319267157230817,
 'support': 18593},
'macro avg': {'precision': 0.5458677521056484,
 'recall': 0.18879162346098552,
 'f1-score': 0.27285493460430515,
 'support': 18593},
'weighted avg': {'precision': 0.5764401531716534,
 'recall': 0.26015166998332706,
 'f1-score': 0.34624404430698164,
 'support': 18593},
'samples avg': {'precision': 0.3603441484028076,
 'recall': 0.26288753146295046,
 'f1-score': 0.28425871924475277,
 'support': 18593}}
```

In [13]:

```
# Logistic regression with limited keywords and production_countries
X_train.head()
logistic_reg(X_train,y_train,X_test,y_test)
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in labels with no predic
ted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Recall an
d F-score are ill-defined and being set to 0.0 in samples with no true la
bels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[13]:

```
{'Animation': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 1300},
 'Comedy': {'precision': 0.09836065573770492,
  'recall': 0.075,
  'f1-score': 0.08510638297872339,
  'support': 720},
 'Family': {'precision': 0.04241071428571429,
  'recall': 0.04702970297029703,
  'f1-score': 0.04460093896713615,
  'support': 404},
 'Adventure': {'precision': 0.33760683760683763,
  'recall': 0.05951035781544256,
  'f1-score': 0.10118475824527698,
  'support': 2655},
 'Fantasy': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
916},
 'Romance': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
796},
 'Drama': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 4
154},
 'Action': {'precision': 0.06016597510373444,
  'recall': 0.05,
  'f1-score': 0.054613935969868174,
  'support': 580},
 'Crime': {'precision': 0.060215053763440864,
  'recall': 0.06153846153846154,
  'f1-score': 0.060869565217391314,
  'support': 455},
 'Thriller': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 327},
 'Horror': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
278},
 'History': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
935},
 'Science Fiction': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 340},
 'Mystery': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
486},
 'War': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 141
1},
 'Foreign': {'precision': 0.0625,
  'recall': 0.04426229508196721,
  'f1-score': 0.051823416506717845,
  'support': 610},
 'Music': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support': 1
64},
 'Documentary': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 1568},
 'Western': {'precision': 0.0, 'recall': 0.0, 'f1-score': 0.0, 'support':
269},
 'TV Movie': {'precision': 0.0,
  'recall': 0.0,
  'f1-score': 0.0,
  'support': 225},
 'micro avg': {'precision': 0.11075949367088607,
```

```
 'recall': 0.016941859839724627,
 'f1-score': 0.02938844054671829,
 'support': 18593},
'macro avg': {'precision': 0.0330629618248716,
 'recall': 0.016867040870308415,
 'f1-score': 0.019909949894255694,
 'support': 18593},
'weighted avg': {'precision': 0.058340174773907474,
 'recall': 0.016941859839724627,
 'f1-score': 0.02360699872716338,
 'support': 18593},
'samples avg': {'precision': 0.0064281621544191375,
 'recall': 0.014881463973642746,
 'f1-score': 0.008117270687103087,
 'support': 18593}}
```

In [14]:

```
# XGBoost with limited keywords and production_countries
xgboost(X_train,y_train,X_test,y_test)
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\x
gboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClass
ifier is deprecated and will be removed in a future release. To remove th
is warning, do the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as integ
ers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Recall an
d F-score are ill-defined and being set to 0.0 in samples with no true la
bels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[14]:

```
{'Animation': {'precision': 0.7453271028037384,
  'recall': 0.2453846153846154,
  'f1-score': 0.36921296296296297,
  'support': 1300},
 'Comedy': {'precision': 0.6994219653179191,
  'recall': 0.16805555555555557,
  'f1-score': 0.27099664053751404,
  'support': 720},
 'Family': {'precision': 0.8706896551724138,
  'recall': 0.25,
  'f1-score': 0.3884615384615385,
  'support': 404},
 'Adventure': {'precision': 0.7602040816326531,
  'recall': 0.16836158192090395,
  'f1-score': 0.2756706753006475,
  'support': 2655},
 'Fantasy': {'precision': 0.6260504201680672,
  'recall': 0.16266375545851527,
  'f1-score': 0.2582322357019064,
  'support': 916},
 'Romance': {'precision': 0.7613636363636364,
  'recall': 0.08417085427135679,
  'f1-score': 0.15158371040723984,
  'support': 796},
 'Drama': {'precision': 0.6886861313868613,
  'recall': 0.454260953298026,
  'f1-score': 0.5474325500435161,
  'support': 4154},
 'Action': {'precision': 0.7037037037037037,
  'recall': 0.1310344827586207,
  'f1-score': 0.22093023255813954,
  'support': 580},
 'Crime': {'precision': 0.6464646464646465,
  'recall': 0.14065934065934066,
  'f1-score': 0.23104693140794225,
  'support': 455},
 'Thriller': {'precision': 0.5,
  'recall': 0.0030581039755351682,
  'f1-score': 0.0060790273556231,
  'support': 327},
 'Horror': {'precision': 0.5476190476190477,
  'recall': 0.08273381294964029,
  'f1-score': 0.14375,
  'support': 278},
 'History': {'precision': 0.8663239074550129,
  'recall': 0.360427807486631,
  'f1-score': 0.5090634441087614,
  'support': 935},
 'Science Fiction': {'precision': 0.616,
  'recall': 0.22647058823529412,
  'f1-score': 0.3311827956989247,
  'support': 340},
 'Mystery': {'precision': 0.5138888888888888,
  'recall': 0.07613168724279835,
  'f1-score': 0.13261648745519714,
  'support': 486},
 'War': {'precision': 0.6723404255319149,
  'recall': 0.11197732104890148,
  'f1-score': 0.19198055893074117,
  'support': 1411},
 'Foreign': {'precision': 0.8392857142857143,
  'recall': 0.38524590163934425,
  'f1-score': 0.5280898876404494,
```

```
 'support': 610},
'Music': {'precision': 0.5384615384615384,
 'recall': 0.042682926829268296,
 'f1-score': 0.0790960451977401,
 'support': 164},
'Documentary': {'precision': 0.7331730769230769,
 'recall': 0.19451530612244897,
 'f1-score': 0.3074596774193548,
 'support': 1568},
'Western': {'precision': 0.7162162162162162,
 'recall': 0.1970260223048327,
 'f1-score': 0.30903790087463556,
 'support': 269},
'TV Movie': {'precision': 0.8640776699029126,
 'recall': 0.39555555555555555,
 'f1-score': 0.5426829268292682,
 'support': 225},
'micro avg': {'precision': 0.7193869489650814,
 'recall': 0.24487710428655945,
 'f1-score': 0.3653799855549314,
 'support': 18593},
'macro avg': {'precision': 0.695464891414898,
 'recall': 0.19402080863485924,
 'f1-score': 0.28973031144460515,
 'support': 18593},
'weighted avg': {'precision': 0.7129451507153145,
 'recall': 0.24487710428655945,
 'f1-score': 0.34511600094984046,
 'support': 18593},
'samples avg': {'precision': 0.3529777252542615,
 'recall': 0.2471959604641169,
 'f1-score': 0.273300101512392,
 'support': 18593}}
```

In [15]:

```
# Use pre-trained model based on Wikipedia 2014 + Gigaword (https://nlp.
model = gensim.downloader.load('glove-wiki-gigaword-50')
```

In [16]:

```
# Takes a string and returns the average of its words vectors.
def string_to_vector(phrase):
    phrase = phrase.lower()
    phrase = ''.join([c for c in phrase if c.isalnum() or c == ' '])
    vectors = np.array([model[word] for word in phrase.split() if word i
    if len(vectors) == 0:
        return np.full(50, np.nan)
    return np.average(vectors, axis=0)

# Takes a list of strings and returns the average of its words vectors.
def string_list_to_vector(phrase_list):
    vector_list = [string_to_vector(phrase) for phrase in phrase_list]
    vector_array = np.array([v for v in vector_list if not np.any(np.isn
    if len(vector_array) == 0:
        return np.full(50, np.nan)
    return np.average(vector_array, axis=0)

# Replaces column col of strings / lists of strings with a column of wor
def string_column_to_vector_column(df, col_name, new_names):
    col = df[col_name]
    if type(col[0]) == str:
        fun = string_to_vector
    else:
        fun = string_list_to_vector
    array = np.array([fun(row) for row in col])
    return df.join(pd.DataFrame(array, columns=new_names, index=df.index
                  rsuffix="_suffix").drop(col_name, axis=1)
```

In [17]:

```
movies_df = original_movies_df.copy() # Reverse all changes to the dataf

title_cols = ['title'+str(i) for i in range(50)]
keywords_cols = ['keywords'+str(i) for i in range(50)]

# Drop rows with empty genres. Maybe we should do that in data_prep?
movies_df = movies_df[movies_df['genres'].apply(lambda x : x != [])]

# Columns 'title' and 'keywords' are transformed using Word2Vec
movies_df = string_column_to_vector_column(movies_df, 'title', title_col
movies_df = string_column_to_vector_column(movies_df, 'keywords', keywor

# Columns 'production_companies', 'production_countries', 'cast', 'genre
# are transformed by limiting the labels and using MultiLabelBinarizer.
movies_df['production_companies'] = limit_labels(movies_df['production_c
movies_df, production_companies_cols = binarize_column(movies_df, 'produ
movies_df['production_countries'] = limit_labels(movies_df['production_c
movies_df, production_countries_cols = binarize_column(movies_df, 'produ
movies_df['cast'] = limit_labels(movies_df['cast'], 50)
movies_df, cast_cols = binarize_column(movies_df, 'cast')

movies_df['genres'] = limit_labels(movies_df['genres'], 50)
movies_df, genres_cols = binarize_column(movies_df, 'genres')

# TODO: Transform the column 'director' - it is not multilabel.
movies_df.head()
```

Out[17]:

	budget	id	original_title	release_date	revenue	director	title0	title1
0	30000000	862	Toy Story	1995-10-30	373554033.0	[John Lasseter]	0.158795	-0.067820
1	65000000	8844	Jumanji	1995-12-15	262797249.0	[Joe Johnston]	-0.025142	-0.792810
2	0	15602	Grumpier Old Men	1995-12-22	0.0	[Howard Deutch]	-0.612903	0.785603
3	16000000	31357	Waiting to Exhale	1995-12-22	81452156.0	[Forest Whitaker]	0.583170	-0.090578
4	0	11862	Father of the Bride Part II	1995-02-10	76578911.0	[Charles Shyer]	0.581018	0.635348

5 rows × 964 columns

In [18]:

```
# Names of the columns that we consider.
# I have only included 'budget', 'revenue', 'title' and 'keywords', as o
cols = ['budget', 'revenue']+title_cols+keywords_cols

# Impute the missing values in 'title' and 'keywords'.
# The missing values in the rest of the columns will not change, as they

#finding out which strategy for imputation_rder is the best
strategies = ['ascending', 'descending', 'roman', 'arabic', 'random']
micro_avg_rf = []
micro_avg_xg = []
macro_avg_rf = []
macro_avg_xg = []
for s in strategies:
    imp = IterativeImputer(imputation_order=s)
    movies_df = movies_df.drop(cols, axis=1).join(
        pd.DataFrame(imp.fit_transform(movies_df[cols]), columns=imp.fea
    train_df, test_df = train_test_split(movies_df, test_size=0.2)
    X_cols = ['budget', 'revenue']+title_cols+keywords_cols+production_c
    X_train = train_df[X_cols]
    X_test = test_df[X_cols]

    y_train = train_df[genres_cols]
    y_test = test_df[genres_cols]

    rf_output = random_forest(X_train,y_train,X_test,y_test)
    xg_output = xgboost(X_train,y_train,X_test,y_test)

    micro_avg_rf.append(rf_output['micro avg'])
    micro_avg_xg.append(xg_output['micro avg'])
    macro_avg_rf.append(rf_output['macro avg'])
    macro_avg_xg.append(xg_output['macro avg'])


print(micro_avg_rf)
print(macro_avg_rf)
print(micro_avg_xg)
print(macro_avg_xg)
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\x
gboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClass
ifier is deprecated and will be removed in a future release. To remove th
is warning, do the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as integ
ers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
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  _warn_prf(average, modifier, msg_start, len(result))
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  _warn_prf(average, modifier, msg_start, len(result))
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  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\x
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is warning, do the following: 1) Pass option use_label_encoder=False when
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ers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
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klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
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cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
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cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\x
gboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClass
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is warning, do the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as integ
ers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
```

```
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\sklearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in samples with no predicted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\sklearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in samples with no predicted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\xgboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClassifier is deprecated and will be removed in a future release. To remove this warning, do the following: 1) Pass option use_label_encoder=False when constructing XGBClassifier object; and 2) Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
[{'precision': 0.7112468407750632, 'recall': 0.18169590013989023, 'f1-score': 0.289448872889346, 'support': 18586}, {'precision': 0.7047560222359481, 'recall': 0.18341102716605048, 'f1-score': 0.2910714285714286, 'support': 18663}, {'precision': 0.7, 'recall': 0.18043944265809217, 'f1-score': 0.2869194716659565, 'support': 18660}, {'precision': 0.7052261929353439, 'recall': 0.1827525293078529, 'f1-score': 0.29028143865317574, 'support': 18681}, {'precision': 0.7141025641025641, 'recall': 0.1788026322829169, 'f1-score': 0.2859554644645073, 'support': 18691}]
[{'precision': 0.8221579025744268, 'recall': 0.08776091651079905, 'f1-score': 0.14214723246187275, 'support': 18586}, {'precision': 0.8324981486922305, 'recall': 0.09190829389339475, 'f1-score': 0.1485989277108873, 'support': 18663}, {'precision': 0.811913148670001, 'recall': 0.08793395123370473, 'f1-score': 0.14140682889114497, 'support': 18660}, {'precision': 0.8182004476311018, 'recall': 0.091694496463873, 'f1-score': 0.1484630409688068, 'support': 18681}, {'precision': 0.8229657397728424, 'recall': 0.08814058236145697, 'f1-score': 0.14349612710304357, 'support': 18691}]
[{'precision': 0.6693041184824507, 'recall': 0.35499838588184657, 'f1-score': 0.46392912389256086, 'support': 18586}, {'precision': 0.6606379807214549, 'recall': 0.35621282751969136, 'f1-score': 0.4628559493142101, 'support': 18663}, {'precision': 0.6526168597682781, 'recall': 0.3501607717041801, 'f1-score': 0.4557756696428572, 'support': 18660}, {'precision': 0.6595399736548789, 'recall': 0.34842888496333174, 'f1-score': 0.4559719789842382, 'support': 18681}, {'precision': 0.6697987948115617, 'recall': 0.35086405221764483, 'f1-score': 0.46050136928586477, 'support': 18691}]
[{'precision': 0.6934639166631456, 'recall': 0.2590711540995434, 'f1-score': 0.3604746112383656, 'support': 18586}, {'precision': 0.6872905317612212, 'recall': 0.26641458968535975, 'f1-score': 0.36787614224909965, 'support': 18663}, {'precision': 0.6741287885800958, 'recall': 0.25803037266948564, 'f1-score': 0.35716216351698404, 'support': 18660}, {'precision': 0.6816322369064445, 'recall': 0.258732628660318, 'f1-score': 0.35941345947473347, 'support': 18681}, {'precision': 0.6833754318479817, 'recall': 0.25653236528494583, 'f1-score': 0.357858784000396, 'support': 18691}]
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\sklearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in samples with no predicted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [19]:

```
print("micro avg rf: ", max(micro_avg_rf,key=lambda x: x['precision']))
print("macro avg rf: ", max(macro_avg_rf,key=lambda x: x['precision']))
print("micro avg xgboost: ", max(micro_avg_xg,key=lambda x: x['precision
print("macro avg xgboost: ", max(macro_avg_xg,key=lambda x: x['precision
```

```
micro avg rf:  {'precision': 0.7141025641025641, 'recall': 0.178802632282
9169, 'f1-score': 0.2859954644645073, 'support': 18691}
macro avg rf:  {'precision': 0.8324981486922305, 'recall': 0.091908293893
39475, 'f1-score': 0.1485989277108873, 'support': 18663}
micro avg xgboost:  {'precision': 0.6697987948115617, 'recall': 0.3508640
5221764483, 'f1-score': 0.46050136928586477, 'support': 18691}
macro avg xgboost:  {'precision': 0.6934639166631456, 'recall': 0.2590711
540995434, 'f1-score': 0.3604746112383656, 'support': 18586}
```

In [20]:

```
# Random forest with:
# - keywords and titles processed by Word2Vec
# - 'production_companies_cols', 'production_countries_cols', 'cast' lim
# - 'budget' and 'revenue'
rfc = RandomForestClassifier()
rfc.fit(X_train, y_train)
y_pred = rfc.predict(X_test)
print(accuracy_score(y_test, y_pred))
classification_report(y_test ,y_pred,target_names=genres_cols, output_di
```

```
0.12490073737946682
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[20]:

```
{'Action': {'precision': 0.8636363636363636,
  'recall': 0.08394698085419734,
  'f1-score': 0.15302013422818792,
  'support': 1358},
 'Adventure': {'precision': 0.8636363636363636,
  'recall': 0.05352112676056338,
  'f1-score': 0.10079575596816975,
  'support': 710},
 'Animation': {'precision': 0.9444444444444444,
  'recall': 0.08717948717948718,
  'f1-score': 0.1596244131455399,
  'support': 390},
 'Comedy': {'precision': 0.757455268389662,
  'recall': 0.14350282485875707,
  'f1-score': 0.24129195693476885,
  'support': 2655},
 'Crime': {'precision': 0.7575757575757576,
  'recall': 0.05263157894736842,
  'f1-score': 0.09842519685039369,
  'support': 950},
 'Documentary': {'precision': 0.8035714285714286,
  'recall': 0.054878048780487805,
  'f1-score': 0.10273972602739724,
  'support': 820},
 'Drama': {'precision': 0.678679588128407,
  'recall': 0.5334444179957153,
  'f1-score': 0.5973610555777689,
  'support': 4201},
 'Family': {'precision': 0.8620689655172413,
  'recall': 0.04638218923933209,
  'f1-score': 0.0880281690140845,
  'support': 539},
 'Fantasy': {'precision': 0.9032258064516129,
  'recall': 0.060215053763440864,
  'f1-score': 0.11290322580645162,
  'support': 465},
 'Foreign': {'precision': 0.7333333333333333,
  'recall': 0.06489675516224189,
  'f1-score': 0.11924119241192412,
  'support': 339},
 'History': {'precision': 0.9375,
  'recall': 0.053003533568904596,
  'f1-score': 0.1003344481605351,
  'support': 283},
 'Horror': {'precision': 0.9130434782608695,
  'recall': 0.06702127659574468,
  'f1-score': 0.1248761149653122,
  'support': 940},
 'Music': {'precision': 0.65,
  'recall': 0.038461538461538464,
  'f1-score': 0.07262569832402235,
  'support': 338},
 'Mystery': {'precision': 0.8235294117647058,
  'recall': 0.051756007393715345,
  'f1-score': 0.0973913043478261,
  'support': 541},
 'Romance': {'precision': 0.7840909090909091,
  'recall': 0.05114899925871016,
  'f1-score': 0.09603340292275574,
  'support': 1349},
 'Science Fiction': {'precision': 0.8985507246376812,
  'recall': 0.09967845659163987,
  'f1-score': 0.17945007235890015,
```

```
 'support': 622},
'TV Movie': {'precision': 1.0,
 'recall': 0.031446540880503145,
 'f1-score': 0.06097560975609756,
 'support': 159},
'Thriller': {'precision': 0.7454545454545455,
 'recall': 0.07889672867222579,
 'f1-score': 0.14269141531322507,
 'support': 1559},
'War': {'precision': 0.7272727272727273,
 'recall': 0.06451612903225806,
 'f1-score': 0.11851851851851852,
 'support': 248},
'Western': {'precision': 1.0,
 'recall': 0.06222222222222222,
 'f1-score': 0.11715481171548117,
 'support': 225},
'micro avg': {'precision': 0.71570492496301,
 'recall': 0.18115670643625273,
 'f1-score': 0.2891298778925796,
 'support': 18691},
'macro avg': {'precision': 0.8323534558083026,
 'recall': 0.08893749481095267,
 'f1-score': 0.14417411111736805,
 'support': 18691},
'weighted avg': {'precision': 0.7843538588261799,
 'recall': 0.18115670643625273,
 'f1-score': 0.24407303503035138,
 'support': 18691},
'samples avg': {'precision': 0.32061826432217805,
 'recall': 0.21308132782324501,
 'f1-score': 0.24185029126038768,
 'support': 18691}}
```

In [21]:

```
# XGBoost with:
# - keywords and titles processed by Word2Vec
# - 'production_companies_cols', 'production_countries_cols', 'cast' lim
# - 'budget' and 'revenue'

# Runs about 13 minutes
xgbc = MultiOutputClassifier(xgb.XGBClassifier())
xgbc.fit(X_train, y_train)
y_pred = xgbc.predict(X_test)
print(accuracy_score(y_test, y_pred))
classification_report(y_test ,y_pred,target_names=genres_cols, output_di
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\x
gboost\sklearn.py:1224: UserWarning: The use of label encoder in XGBClass
ifier is deprecated and will be removed in a future release. To remove th
is warning, do the following: 1) Pass option use_label_encoder=False when
constructing XGBClassifier object; and 2) Encode your labels (y) as integ
ers starting with 0, i.e. 0, 1, 2, ..., [num_class - 1].
  warnings.warn(label_encoder_deprecation_msg, UserWarning)
0.15507657402155417
```

```
C:\Users\natal\AppData\Local\Programs\Python\Python37\lib\site-packages\s
klearn\metrics\_classification.py:1318: UndefinedMetricWarning: Precision
and F-score are ill-defined and being set to 0.0 in samples with no predi
cted labels. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Out[21]:

```
{'Action': {'precision': 0.7005730659025788,
  'recall': 0.3600883652430044,
  'f1-score': 0.4756809338521401,
  'support': 1358},
 'Adventure': {'precision': 0.6285714285714286,
  'recall': 0.21690140845070421,
  'f1-score': 0.3225130890052356,
  'support': 710},
 'Animation': {'precision': 0.9171974522292994,
  'recall': 0.36923076923076925,
  'f1-score': 0.526508226691042,
  'support': 390},
 'Comedy': {'precision': 0.6428571428571429,
  'recall': 0.36610169491525424,
  'f1-score': 0.4665226781857452,
  'support': 2655},
 'Crime': {'precision': 0.6445012787723785,
  'recall': 0.26526315789473687,
  'f1-score': 0.37583892617449666,
  'support': 950},
 'Documentary': {'precision': 0.6846153846153846,
  'recall': 0.21707317073170732,
  'f1-score': 0.3296296296296296,
  'support': 820},
 'Drama': {'precision': 0.6677026677026677,
  'recall': 0.6136634134729826,
  'f1-score': 0.6395435375837261,
  'support': 4201},
 'Family': {'precision': 0.8083832335329342,
  'recall': 0.2504638218923933,
  'f1-score': 0.38243626062322944,
  'support': 539},
 'Fantasy': {'precision': 0.6347826086956522,
  'recall': 0.15698924731182795,
  'f1-score': 0.2517241379310345,
  'support': 465},
 'Foreign': {'precision': 0.5957446808510638,
  'recall': 0.08259587020648967,
  'f1-score': 0.14507772020725387,
  'support': 339},
 'History': {'precision': 0.62,
  'recall': 0.10954063604240283,
  'f1-score': 0.1861861861861862,
  'support': 283},
 'Horror': {'precision': 0.7461368653421634,
  'recall': 0.3595744680851064,
  'f1-score': 0.4852835606604452,
  'support': 940},
 'Music': {'precision': 0.6610169491525424,
  'recall': 0.23076923076923078,
  'f1-score': 0.34210526315789475,
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