

Report

Predictive Analytics *The Project Of Group 6*

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Area: Data Science
Course: Predictive Analytics
Course Code: D7056E
Date: March 10, 2024
Semester: VT 2024

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1 Introduction

This document serves as a report to summarize the project. Be advised that Appendix A contains the improved notebooks used for the project. All members have contributed to the project, with more or less the same level of effort to achieve the shared goals. The entire project process was iterative, which implies that the iterative process added time to the phases accordingly.

Table 1.1: Time Distribution for Project Phases (in Percentage)

Project Phase	Time Spent (%)
Problem Understanding	5.88%
Data Understanding	11.76%
Data Preparation	8.82%
Modeling	38.24%
Evaluation	17.65%
Presentation and Report	17.65%

This work follows the CRISP-DM framework to enhance Netflix's customer retention through data analysis. The process begins with understanding the business case and improving customer satisfaction and loyalty by better matching services to customer needs through predictive modeling. Netflix collects customer data, including interactions and preferences, to analyze and improve customer satisfaction and the likelihood of subscription renewal. Despite the effectiveness of Netflix's data-driven approach, ethical and legal concerns regarding data collection practices have arisen. A specific focus is placed on a data-driven product recommendation solution, using data sources to provide relevant and personalized customer suggestions. Data collection involved finding a dataset rich enough for predictive analysis without compromising customer privacy. However, the challenge was acquiring data rich in features to produce a predictive analysis that could achieve the objectives and maintain customer privacy, as this was a concern. The aim of the project is to consider all ethical considerations. After an executive searched the Internet for suitable and relevant data for the business case, the exploratory process resulted in finding a data set that may be used to achieve the project objectives. The Kaggle Netflix TV shows and movies data set¹ was used, which contains information on shows and movies without personal customer data.

¹<https://www.kaggle.com/datasets/thedevastator/the-ultimate-netflix-tv-shows-and-movies-dataset>

Table 1.2: Dataset Columns Overview

Index	Column	Non-Null Count	Dtype
0	ShowId	8807 non-null	object
1	Type	8807 non-null	object
2	Title	8807 non-null	object
3	Director	6173 non-null	object
4	Cast	7982 non-null	object
5	Country	7976 non-null	object
6	DateAdded	8797 non-null	object
7	Release Year	8807 non-null	int64
8	Rating	8803 non-null	object
9	Duration	8804 non-null	object
10	ListedIn	8807 non-null	object
11	Description	8807 non-null	object

The data preparation phase involved identifying key features for analysis and pre-processing the data for modeling. Several models were selected for this project, including Random Forest Classifier, Multilayer Perceptron, Decision Tree Classifier, and Keras Neural Network, each offering different strengths in handling the data and predicting outcomes. Models were evaluated based on cross-validation, precision, recall, F1 score, and Hamming loss, focusing on multi-label classification for gene prediction. Although deployment was beyond this project's scope, considerations were made for potential implementation using tools like Flask, Docker, and Kubernetes to monitor model performance and impact on business objectives, such as customer retention rates.

Table 1.3: Analysis Features: Identified Features

Feature	Category
Description	Independent Feature
ListedIn	Target Feature

Initially, text descriptions were normalized (lowercase, tokenized, and lemmatized) and vectorized using TF-IDF. Two approaches were selected for modeling: Information-Based Modeling (Decision Tree and Random Forest Classifiers) and Neural Networks (Keras Neural Network and Multilayer Perceptron) to identify complex patterns to generate recommendations based on the movie description. The chosen models aimed to handle non-linear relationships, reduce overfitting, and model complex relationships effectively. The target feature was converted into a binary matrix using MultiLabelBinarizer for genre assignment. Model performance was evaluated through cross-validation, precision, recall, F1, and Hamming loss metrics. Although deployment was beyond the scope, considerations were made for using Flask, Docker, and Kubernetes for future model deployment and monitoring, meaning the models can be deployed in operational settings. It was discovered that the initial evaluation metrics were misleading as they did not consider the multilabel classification; therefore, the Accuracy scores had discrepancies from the other measurement metrics. Thus, improvements were made after the presentation, such as adapting several other practices for evaluating multilabel classification models, including cross-validation. The evaluation of four models on a multilabel classification

task reveals an imbalance between precision and recall across the models, with varying levels of accuracy and hamming loss. The latter implies that the Neural Network model offers the best overall balance between accuracy, precision, recall, and F1 score, making it the most suitable choice among the models evaluated for this specific task. The Random Forest and Keras Neural Network models show high precision but at the cost of lower recall, indicating they are discreet in predicting labels. The Decision Tree model struggles with the most insufficient accuracy and the highest hamming loss, suggesting it makes the most mistakes in label prediction. Despite some models showing strengths in certain areas (such as precision), all models have relatively low accuracy, indicating a need for further optimization, whether through model tuning or exploring alternative modeling techniques. This may be due to the complex balance between different metrics in multilabel classification. However, the strength of the project is that the Neural Network models show the best overall balance between accuracy, precision, recall, and F1-score. This indicates their capability to handle complex patterns and relationships within the data effectively. This implies the Neural Network models show promising potential for this case, but that would require optimizing and improving the models through fine-tuning or acquiring richer data, given the data used for this project was not sufficiently rich and it was challenging to obtain richer data.

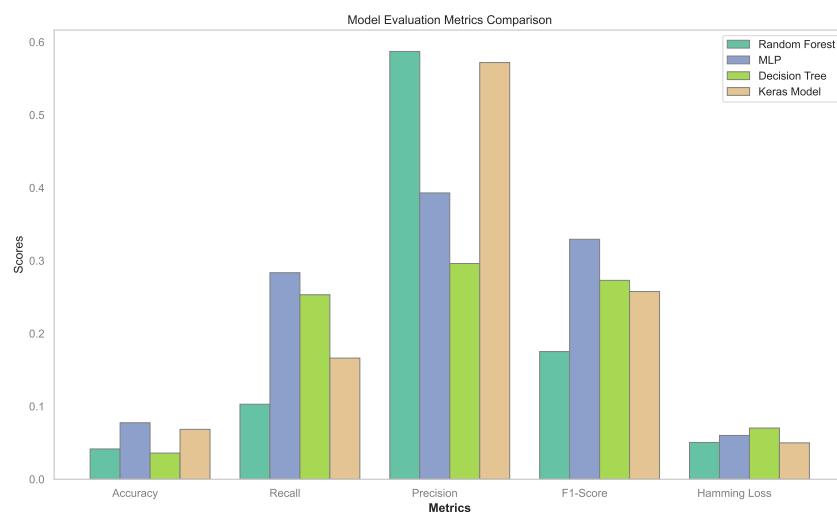


Figure 1.1: Model Evaluation Metrics Comparison

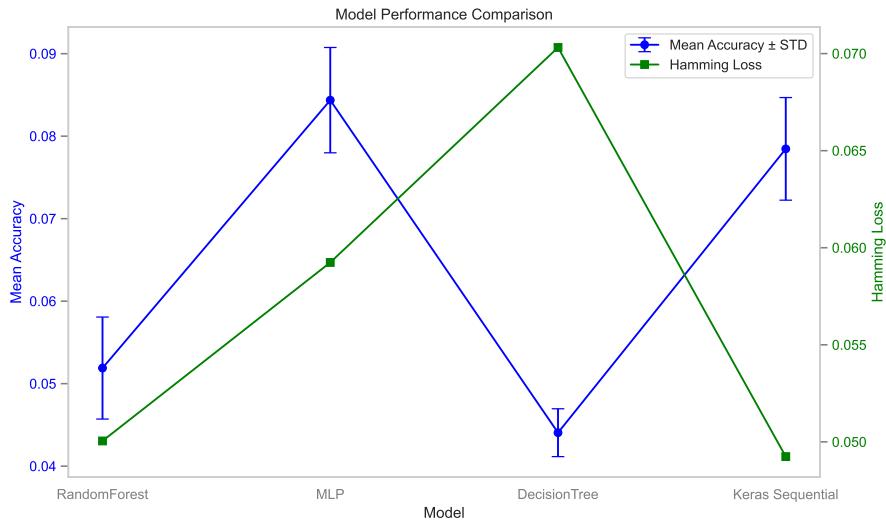


Figure 1.2: Cross-Validation: Model Performance Comparison

After the presentation, it was decided to improve the analysis using Kmeans with TF-IDF clustering the relationships. One improvement is a recommendation function where a particular movie and a list of related movies are suggested based on the relationships net visualized in the charts and graphs, and a list of associated films is suggested.

Table 1.4: Initial Recommendations

Movie Title	Score
The Whole Truth	2.345136
Seabiscuit	1.723801
The Lincoln Lawyer	1.723801
Roxanne Roxanne	1.723801
Dark Skies	1.584363

Table 1.5: Recommendations for 'Dark Skies'

Movie Title	Score
Real Steel	1.801042
Free State of Jones	1.584363
Skylines	1.014437
The Meddler	0.863015
The Late Bloomer	0.863015

The data used for the project was 8807 rows in size. The training set, approximately, 6164 rows, was 70% of the total group, and the test set, 2643 rows, was 30% of the entire collection.

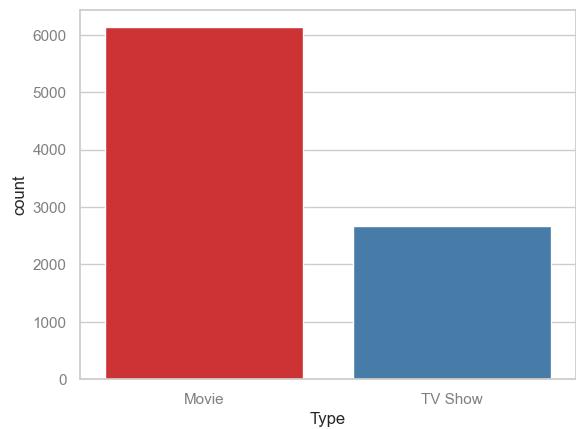


Figure 1.3: Picture Type Distribution

In summary, the project shows that Neural Network models possess the potential to solve the task of this project. However, that would require richer data and optimization and improvements to the models, such as adjusting the learning process to focus more on the underrepresented classes by using class weights or custom loss functions, fine-tuning, or other techniques.

A Appendix

Project-Group-6

March 10, 2024

1 NETFLIX DATA DRIVEN PRODUCT RECOMMENDATION

1.1 Group 6 Project Assignment

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1.1.1 The Business Case

Enhancing Customer Retention through Data Analysis

Netflix, a leading video streaming platform, has achieved commendable customer retention rates through its robust customer analysis efforts.

However, the journey to this success has been complex and multifaceted, involving collecting and analyzing vast amounts of customer data.

1.1.2 The Problem

Understanding customer preferences, behaviors, and satisfaction levels is a significant challenge. Netflix aims to enhance customer satisfaction and loyalty by customizing its services to meet customer needs and expectations better.

This involves using predictive models to identify areas for improvement, refine content recommendations, enhance the user experience, and ultimately increase customer satisfaction and loyalty.

Data Collection and Analysis

Netflix collects a wide range of data, including basic customer information (age, gender, nationality), customer interactions within the application or website (devices used, viewing duration, content preferences), and all user actions on the platform.

This data is the foundation for analyzing targets such as customer satisfaction, preferences, and the likelihood of subscription renewal.

Results and Controversies

While Netflix has achieved its objectives, with rising customer retention rates and a substantial number of customers following the recommendation algorithms, its data collection has raised ethical and legal questions.

Despite informing customers of user agreements and privacy policies, the reality is that few people read these lengthy and complex documents.

This raises concerns about the transparency and ethics of data collection.

1.1.3 The Opportunity

Despite these challenges, data analysis has immense potential for enhancing customer retention. With a customer retention rate of 93% and a churn rate of around 2.4%, Netflix's data-driven approach has proven to be highly effective.

However, there is always room for improvement and innovation, particularly in addressing data collection's ethical and legal implications.

1.1.4 The Objective

Investing in this project would involve funding to enhance the data analysis capabilities further while addressing ethical and legal concerns.

This could involve developing more transparent data collection practices, investing in advanced data analysis tools, and implementing measures to ensure the ethical use of data. The potential return on investment is significant, given the proven effectiveness of data-driven customer retention strategies.

In conclusion, this project presents a unique opportunity to leverage data analysis to enhance customer retention while addressing data collection's ethical and legal implications.

1.2 Product recommendation solution

The chosen subject is a data-driven product recommendation solution among the many solutions because it has several advantages over the customer segmentation and profiling solution and other possible solutions.

First, the data-driven product recommendation solution can leverage the internal data sources that the company already has, such as customer purchase history, browsing behavior, ratings, reviews, and preferences. This means that the company does not need to rely on external data sources that may be costly, unreliable, or outdated.

Second, the data-driven product recommendation solution can provide more personalized and relevant suggestions to each customer based on their unique needs and interests. This can increase customer satisfaction, loyalty, and retention and boost sales and revenue.

Third, the data-driven product recommendation solution can adapt to changing customer behavior and preferences using machine learning algorithms that can learn from new data and feedback. This can ensure that the recommendations are always up-to-date and accurate and uncover new patterns and opportunities for the company.

1.3 Implementation

The task is to personalize movie recommendation approach, we are employing four different modeling approaches: information-based models and neural networks; Random Forest Classifier, Multi-layer Perceptron, Keras Neural Network, and Decision Tree Classifier. By vectorizing movie descriptions using TF-IDF and applying these advanced modeling techniques, we not only enhance

our recommendation system's accuracy but also ensure compliance with legal obligations regarding customer privacy and ethical considerations. This approach allows us to dynamically suggest movies based on individual preferences while safeguarding customer information.s:

These models leverage decision trees or rule-based systems to segment data according to various criteria, including entropy, information gain, or the Gini index. They excel in identifying pivotal features and variables that influence customer preferences, facilitating the generation of specific rules or paths for diverse product recommendations. The clear, logical structure of information-based models enhances their interpretability and ease of explanation, making them highly adaptable and scalable to various data types and new data sources. Neural Networks:on systems.

To set up the environment for these modeling approaches, we are going to perform the following steps:

- Import the relevant libraries and packages, such as pandas, numpy, scikit-learn, tensorflow, keras, etc.
- Load and preprocess the data, such as removing missing values, outliers, duplicates, etc.
- Perform exploratory data analysis, such as visualizing the data, calculating summary statistics, identifying correlations, etc.
- Split the data into training, validation, and testing sets and apply feature engineering, scaling, encoding,models. optimizers, loss functions, etc.
- Evaluate and compare the performance of the models, such as using accuracy, precision, recall, F1-score, etc., and select the best model based on the results.
- We would then be able to deploy and monitor the model, such as using Flask, Docker, Kubernetes, etc., and collect feedback and metrics, such as click-through rate, conversion rate, etc.

1.3.1 Import Packages

```
[1]: import warnings  
warnings.filterwarnings('ignore')
```

```
[2]: %%capture  
!pip install pandas_profiling  
!pip install pydantic-settings  
!pip install bump-pydantic  
!pip install -U pydantic  
!pip install AutoViz  
!pip install hdbscan  
!pip install --upgrade tensorflow
```

```
[3]: %%capture  
import numpy as np  
import pandas as pd  
import matplotlib.pyplot as plt  
import seaborn as sns
```

```

import math as math
from autoviz.AutoViz_Class import AutoViz_Class
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.decomposition import PCA
from sklearn.model_selection import cross_val_score
from sklearn.neural_network import MLPClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import MultiLabelBinarizer
from sklearn.multioutput import MultiOutputClassifier
from sklearn.tree import DecisionTreeClassifier, plot_tree
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, recall_score, precision_score, f1_score, hamming_loss, make_scorer
from sklearn.inspection import permutation_importance
from sklearn.model_selection import KFold
from sklearn.base import clone
from sklearn.multiclass import OneVsRestClassifier
from sklearn.metrics.pairwise import linear_kernel
from sklearn.cluster import MiniBatchKMeans
from hdbscan import HDBSCAN
from keras.models import Sequential
from keras.layers import Dense
from sklearn.model_selection import cross_val_score, StratifiedKFold
import nltk
from nltk.stem.porter import PorterStemmer
import spacy
from scipy.sparse import csr_matrix
nlp = spacy.load('en_core_web_sm')
nltk.download('stopwords', quiet=True)
nltk.download('punkt', quiet=True)
%matplotlib inline

```

1.3.2 Predefined Methods

```
[4]: def to_pascal_case(s):
    return ''.join(word.title() for word in s.split('_'))
```

```
[5]: def preprocess_text(text):
    nlp.max_length = len(text) + 1
    doc = nlp(text.lower())
    l_tokens = []
    s_tokens = []
    stemmer = PorterStemmer()
    allowed_postags = ["NOUN", "ADJ", "VERB", "ADV"]
    for token in doc:
        if (
            not token.is_stop

```

```

        and token.pos_ in allowed_postags
        and not token.is_punct
        and not token.is_digit
        and token.is_alpha
    ):

        l_token = token.lemma_
        s_token = stemmer.stem(token.text)
        l_tokens.append(l_token)
        s_tokens.append(s_token)

    l_tokens = " ".join(l_tokens)
    s_tokens = " ".join(s_tokens)
    return l_tokens, s_tokens

```

```
[6]: def create_model():
    model_k = Sequential()
    model_k.add(Dense(units=64, activation='relu', input_dim=X_train.shape[1]))
    model_k.add(Dense(units=Y_train.shape[1], activation='sigmoid'))
    model_k.compile(optimizer='adam', loss='binary_crossentropy',  
→metrics=['accuracy'])
    return model_k
```

```
[7]: def cross_validate_multilabel_model(model, X, Y, cv=5, model_type='sklearn'):
    kf = KFold(n_splits=cv, random_state=42, shuffle=True)
    accuracy_scores = []
    hamming_losses = []

    for train_index, test_index in kf.split(X):
        X_train_fold, X_test_fold = X[train_index], X[test_index]
        Y_train_fold, Y_test_fold = Y[train_index], Y[test_index]

        if model_type == 'keras':
            model = create_model()
            model.fit(X_train_fold.toarray(), Y_train_fold, epochs=10,  
→batch_size=32, verbose=0)
            predictions = model.predict(X_test_fold.toarray())
            predictions_binary = (predictions > 0.5).astype(int)
        else:
            model.fit(X_train_fold, Y_train_fold)
            predictions_binary = model.predict(X_test_fold)

        acc = accuracy_score(Y_test_fold, predictions_binary)
        hl = hamming_loss(Y_test_fold, predictions_binary)

        accuracy_scores.append(acc)
        hamming_losses.append(hl)
```

```

    return np.mean(accuracy_scores), np.std(accuracy_scores), np.
    mean(hamming_losses)

```

[8]:

```

def evaluate_model(model, X_test, Y_test, model_type='sklearn'):
    if model_type == 'keras':
        X_test_eval = X_test.toarray() if 'toarray' in dir(X_test) else X_test
        Y_pred = model.predict(X_test_eval)
        Y_pred = (Y_pred > 0.5).astype(int)
    else:
        Y_pred = model.predict(X_test)

    metrics = {
        'Accuracy': accuracy_score(Y_test, Y_pred),
        'Recall': recall_score(Y_test, Y_pred, average='micro'),
        'Precision': precision_score(Y_test, Y_pred, average='micro'),
        'F1-Score': f1_score(Y_test, Y_pred, average='micro'),
        'Hamming Loss': hamming_loss(Y_test, Y_pred)
    }

    return metrics

```

[9]:

```

def multi_label_accuracy(y_true, y_pred):
    return accuracy_score(y_true, y_pred, normalize=True)

```

[10]:

```

scorers = {
    'accuracy': make_scorer(multi_label_accuracy),
    'precision': 'precision_samples',
    'recall': 'recall_samples',
    'f1': 'f1_samples',
    'hamming_loss': make_scorer(hamming_loss)
}

```

[11]:

```

def get_recommendation(root):
    commons_dict = {}
    for e in G.neighbors(root):
        for e2 in G.neighbors(e):
            if e2 == root:
                continue
            if 'label' in G.nodes[e2] and G.nodes[e2]['label'] == "MOVIE":
                commons = commons_dict.get(e2)
                if commons is None:
                    commons_dict.update({e2: [e]})
                else:
                    commons.append(e)
                    commons_dict.update({e2: commons})
    movies = []
    weight = []

```

```

for key, values in commons_dict.items():
    w = 0.0
    for e in values:
        w = w + 1 / math.log(G.degree(e))
    movies.append(key)
    weight.append(w)

result = pd.Series(data=np.array(weight), index=movies)
result.sort_values(inplace=True, ascending=False)
return result

```

1.3.3 Import Dataset

[12]: df = pd.read_csv('netflix_titles.csv')

1.3.4 Preprocess the data

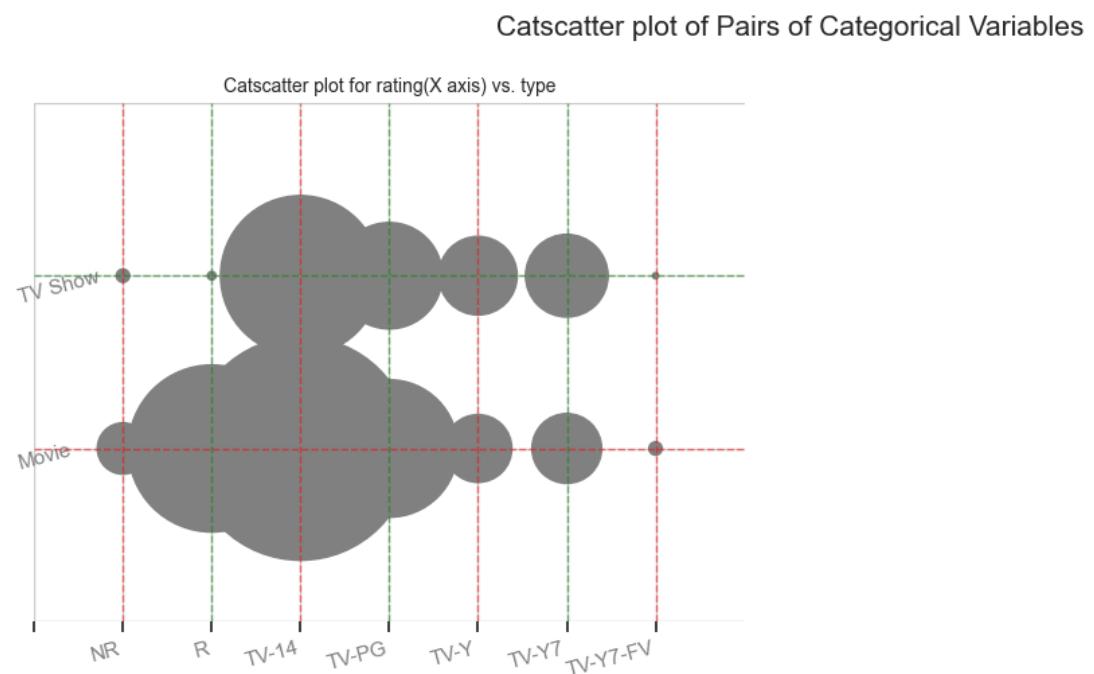
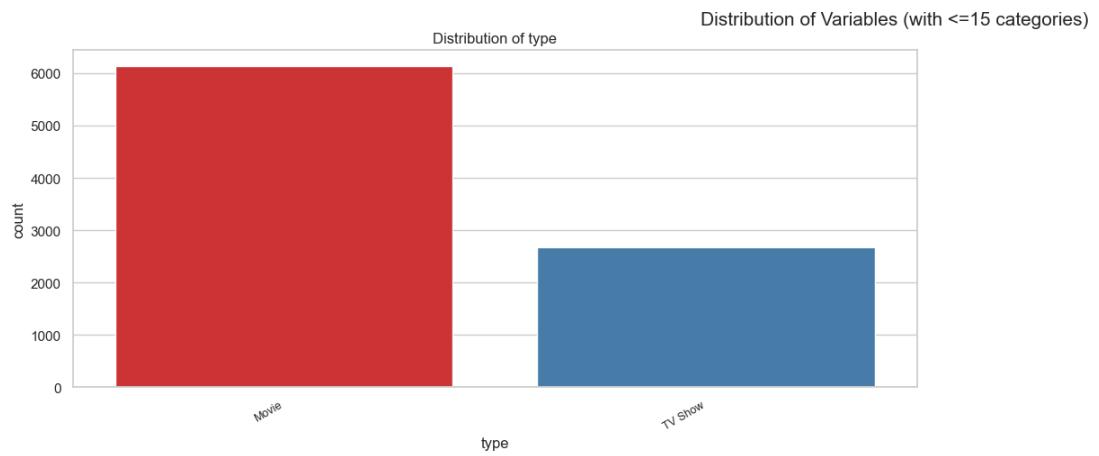
[13]: autoviz = AutoViz_Class().AutoViz('netflix_titles.csv')

```

Shape of your Data Set loaded: (8807, 12)
#####
##### C L A S S I F Y I N G   V A R I A B L E S
#####
Classifying variables in data set...
Number of Numeric Columns = 0
Number of Integer-Categorical Columns = 0
Number of String-Categorical Columns = 1
Number of Factor-Categorical Columns = 0
Number of String-Boolean Columns = 1
Number of Numeric-Boolean Columns = 0
Number of Discrete String Columns = 3
Number of NLP String Columns = 5
Number of Date Time Columns = 1
Number of ID Columns = 1
Number of Columns to Delete = 0
12 Predictors classified...
1 variable(s) removed since they were ID or low-information variables
List of variables removed: ['show_id']
To fix these data quality issues in the dataset, import FixDQ from autoviz...
All variables classified into correct types.

<pandas.io.formats.style.Styler at 0x1d654ee1d90>
Could not draw Distribution Plot

```





Wordcloud for description

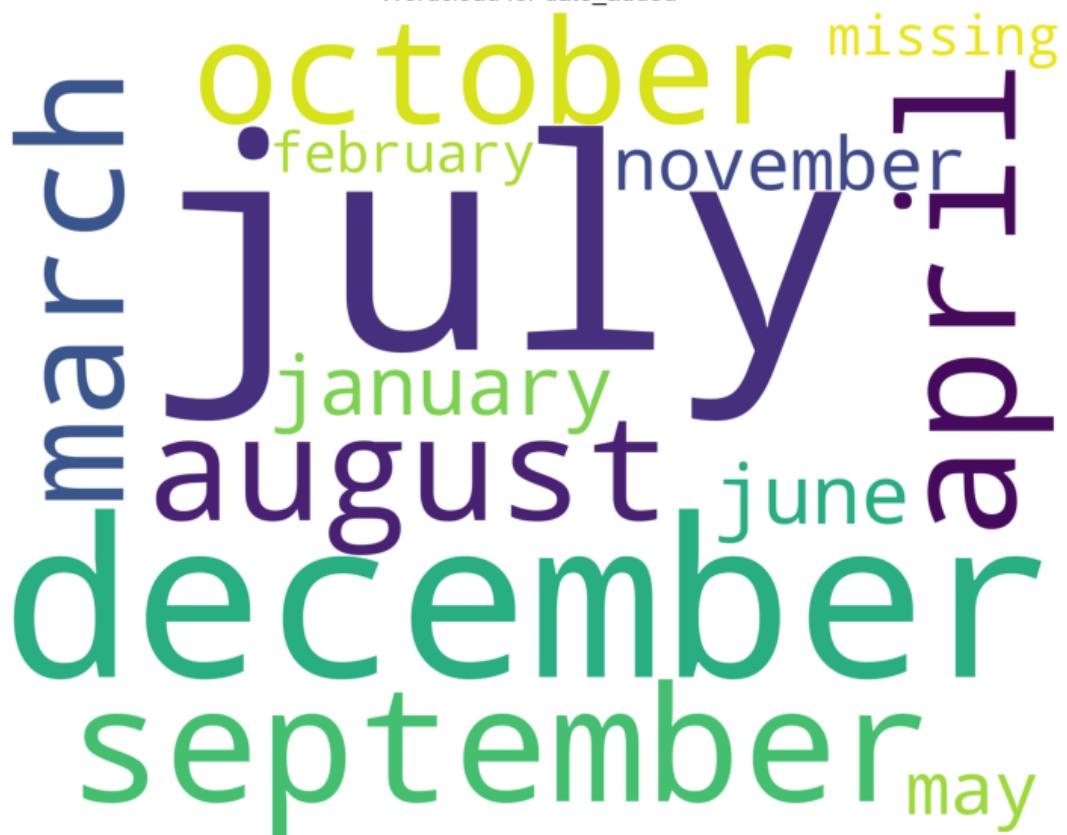




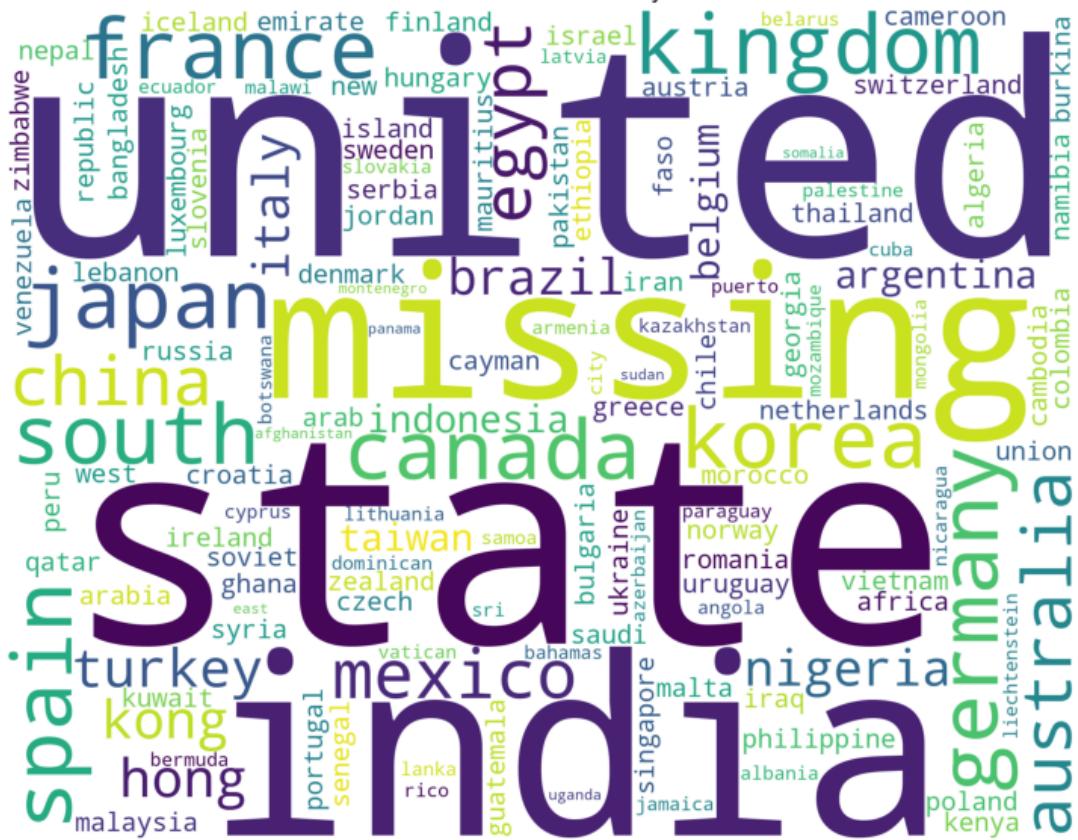
Wordcloud for cast



Wordcloud for date_added



Wordcloud for country



Wordcloud for duration

missing
min
season



All Plots done

Time to run AutoViz = 56 seconds

AUTO VISUALIZATION Completed

```
[14]: df.columns = [to_pascal_case(column) for column in df.columns]

[15]: df = df.drop_duplicates()

[16]: df['TypeCode'] = df['Type'].apply(lambda x: 1 if x == 'Movie' else 0)

[17]: unique_ratings = df['Rating'].unique()
rating_to_code = {rating: code for code, rating in enumerate(unique_ratings)}
df['RatingCode'] = df['Rating'].map(rating_to_code)

[18]: df = df[df['Description'] != 'Unknown']
df = df[df['ListedIn'] != 'Unknown']
df = df.dropna(subset=['Description', 'ListedIn'])
```

```
[19]: lemmatized_text, stemmed_text = zip(*[preprocess_text(item) for item in df['Description']])
lemmatized_text, stemmed_text = list(lemmatized_text), list(stemmed_text)

[20]: df['DescriptionProcessed'] = lemmatized_text

[21]: df['Genres'] = df['ListedIn'].apply(lambda x: x.split(', '))

[22]: df.shape

[22]: (8807, 16)

[23]: df.head()

[23]:   ShowId      Type          Title        Director    \
0     s1      Movie    Dick Johnson Is Dead  Kirsten Johnson
1     s2  TV Show       Blood & Water           NaN
2     s3  TV Show        Ganglands  Julien Leclercq
3     s4  TV Show  Jailbirds New Orleans           NaN
4     s5  TV Show        Kota Factory           NaN

                                                Cast
\                                          
0
NaN
1  Ama Qamata, Khosi Ngema, Gail Mabalane, Thabang Molaba, Dillon Windvogel,
Natasha Thahane, Arno Greeff, Xolile Tshabalala, Getmore Sithole, Cindy
Mahlangu, Ryle De Morny, Greteli Fincham, Sello Maake Ka-Ncube, Odwa Gwanya,
Mekaila Mathys, Sandi Schultz, Duane Williams, Shamilla Miller, Patrick Mofokeng
2
Sami Bouajila, Tracy Gotoas, Samuel Jouy, Nabiha Akkari, Sofia Lesaffre, Salim
Kechiouche, Noureddine Farihi, Geert Van Rampelberg, Bakary Diombera
3
NaN
4
Mayur More, Jitendra Kumar, Ranjan Raj, Alam Khan, Ahsaas Channa, Revathi
Pillai, Urvi Singh, Arun Kumar

      Country      DateAdded  ReleaseYear Rating Duration    \
0  United States  September 25, 2021      2020  PG-13   90 min
1  South Africa  September 24, 2021      2021  TV-MA  2 Seasons
2            NaN  September 24, 2021      2021  TV-MA   1 Season
3            NaN  September 24, 2021      2021  TV-MA   1 Season
4            India  September 24, 2021      2021  TV-MA  2 Seasons

      ListedIn
0
Documentaries
```

```
1           International TV Shows, TV Dramas, TV Mysteries
2 Crime TV Shows, International TV Shows, TV Action & Adventure
3                               Docuseries, Reality TV
4           International TV Shows, Romantic TV Shows, TV Comedies
```

Description

```
\
```

```
0 As her father nears the end of his life, filmmaker Kirsten Johnson stages his death in inventive and comical ways to help them both face the inevitable.
```

```
1 After crossing paths at a party, a Cape Town teen sets out to prove whether a private-school swimming star is her sister who was abducted at birth.
```

```
2 To protect his family from a powerful drug lord, skilled thief Mehdi and his expert team of robbers are pulled into a violent and deadly turf war.
```

```
3 Feuds, flirtations and toilet talk go down among the incarcerated women at the Orleans Justice Center in New Orleans on this gritty reality series.
```

```
4 In a city of coaching centers known to train India's finest collegiate minds, an earnest but unexceptional student and his friends navigate campus life.
```

	TypeCode	RatingCode	\
0	1	0	
1	0	1	
2	0	1	
3	0	1	
4	0	1	

DescriptionProcessed

```
\
```

```
0           father near end life filmmaker kirsten stage death inventive
comical way help face inevitable
```

```
1           cross path party cape town teen set prove private school
swimming star sister abduct birth
```

```
2           protect family powerful drug skilled thief mehdi expert team
robber pull violent deadly turf war
```

```
3           feud flirtation toilet talk incarcerated
woman new gritty reality series
```

```
4 city coach center know train fine collegiate mind earnest unexceptional
student friend navigate campus life
```

Genres

0	[Documentaries]
1	[International TV Shows, TV Dramas, TV Mysteries]
2	[Crime TV Shows, International TV Shows, TV Action & Adventure]
3	[Docuseries, Reality TV]
4	[International TV Shows, Romantic TV Shows, TV Comedies]

```
[24]: df.tail()
```

[24]: ShowId Type Title Director \

8802	s8803	Movie	Zodiac	David Fincher
8803	s8804	TV Show	Zombie Dumb	Nan
8804	s8805	Movie	Zombieland	Ruben Fleischer
8805	s8806	Movie	Zoom	Peter Hewitt
8806	s8807	Movie	Zubaan	Mozez Singh

Cast \

8802	Mark Ruffalo, Jake Gyllenhaal, Robert Downey Jr., Anthony Edwards, Brian Cox, Elias Koteas, Donal Logue, John Carroll Lynch, Dermot Mulroney, Chloë Sevigny
8803	Nan
8804	Jesse Eisenberg, Woody Harrelson, Emma Stone, Abigail Breslin, Amber Heard, Bill Murray, Derek Graf
8805	Tim Allen, Courteney Cox, Chevy Chase, Kate Mara, Ryan Newman, Michael Cassidy, Spencer Breslin, Rip Torn, Kevin Zegers
8806	Vicky Kaushal, Sarah-Jane Dias, Raaghav Chanana, Manish Chaudhary, Meghna Malik, Malkeet Rauni, Anita Shabdish, Chittaranjan Tripathy

Country DateAdded ReleaseYear Rating Duration \

8802	United States	November 20, 2019	2007	R	158 min
8803	Nan	July 1, 2019	2018	TV-Y7	2 Seasons
8804	United States	November 1, 2019	2009	R	88 min
8805	United States	January 11, 2020	2006	PG	88 min
8806	India	March 2, 2019	2015	TV-14	111 min

ListedIn \

8802	Cult Movies, Dramas, Thrillers
8803	Kids' TV, Korean TV Shows, TV Comedies
8804	Comedies, Horror Movies
8805	Children & Family Movies, Comedies
8806	Dramas, International Movies, Music & Musicals

Description \

8802	A political cartoonist, a crime reporter and a pair of cops investigate San Francisco's infamous Zodiac Killer in this thriller based on a true story.
8803	While living alone in a spooky town, a young girl befriends a motley crew of zombie children with diverse personalities.
8804	Looking to survive in a world taken over by zombies, a dorky college student teams with an urban roughneck and a pair of grifter sisters.
8805	Dragged from civilian life, a former superhero must train a new crop of youthful saviors when the military preps for an attack by a familiar villain.

8806 A scrappy but poor boy worms his way into a tycoon's dysfunctional family, while facing his fear of music and the truth about his past.

	TypeCode	RatingCode	\
8802	1	7	
8803	0	6	
8804	1	7	
8805	1	2	
8806	1	3	

DescriptionProcessed

\

8802 political cartoonist crime reporter pair cop investigate infamous zodiac killer thriller base true story

8803 live spooky town young girl befriend motley crew zombie child diverse personality

8804 look survive world take zombie college student team urban roughneck pair grifter sister

8805 drag civilian life superhero train new crop youthful savior military prep attack familiar villain

8806 scrappy poor boy worm way tycoon dysfunctional family face fear music truth past

Genres

8802	[Cult Movies, Dramas, Thrillers]
8803	[Kids' TV, Korean TV Shows, TV Comedies]
8804	[Comedies, Horror Movies]
8805	[Children & Family Movies, Comedies]
8806	[Dramas, International Movies, Music & Musicals]

[25]: main_df = df.copy()

[26]: df.isnull().sum()

ShowId	0
Type	0
Title	0
Director	2634
Cast	825
Country	831
DateAdded	10
ReleaseYear	0
Rating	4
Duration	3
ListedIn	0
Description	0

```
TypeCode          0  
RatingCode        0  
DescriptionProcessed 0  
Genres            0  
dtype: int64
```

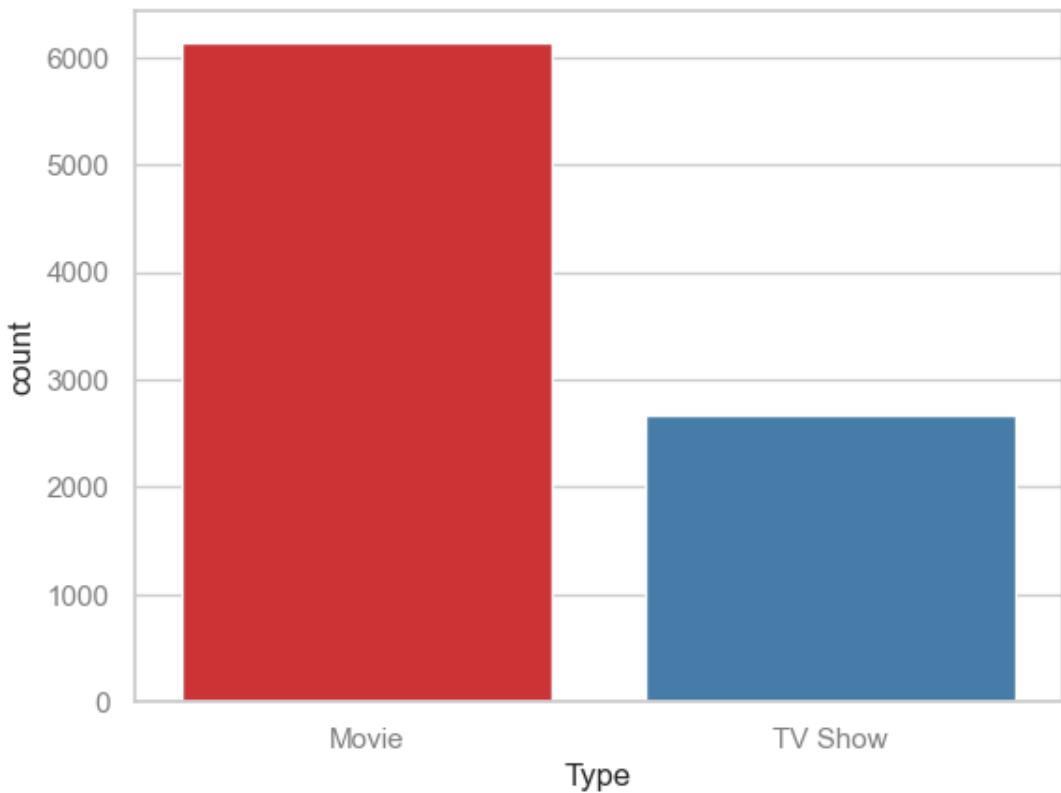
[27]: df.info()

```
<class 'pandas.core.frame.DataFrame'>  
Int64Index: 8807 entries, 0 to 8806  
Data columns (total 16 columns):  
 #   Column           Non-Null Count  Dtype     
---  --  
 0   ShowId          8807 non-null    object    
 1   Type             8807 non-null    object    
 2   Title            8807 non-null    object    
 3   Director         6173 non-null    object    
 4   Cast              7982 non-null    object    
 5   Country           7976 non-null    object    
 6   DateAdded        8797 non-null    object    
 7   ReleaseYear      8807 non-null    int64    
 8   Rating            8803 non-null    object    
 9   Duration          8804 non-null    object    
 10  ListedIn         8807 non-null    object    
 11  Description       8807 non-null    object    
 12  TypeCode          8807 non-null    int64    
 13  RatingCode        8807 non-null    int64    
 14  DescriptionProcessed 8807 non-null    object    
 15  Genres            8807 non-null    object    
dtypes: int64(3), object(13)  
memory usage: 1.1+ MB
```

[28]: df.describe()

```
ReleaseYear     TypeCode     RatingCode  
count    8807.000000  8807.000000  8807.000000  
mean     2014.180198  0.696151   2.993869  
std      8.819312   0.459944   2.490766  
min     1925.000000  0.000000   0.000000  
25%    2013.000000  0.000000   1.000000  
50%    2017.000000  1.000000   3.000000  
75%    2019.000000  1.000000   4.000000  
max     2021.000000  1.000000   17.000000
```

[29]: sns.countplot(data=df, x='Type')
plt.show()



1.3.5 Training Data

```
[30]: print('The total rows of the Training Data:', len(df['DescriptionProcessed']))
```

The total rows of the Training Data: 8807

```
[31]: mlb = MultiLabelBinarizer()
Y = mlb.fit_transform(df['Genres'])
```

```
[32]: vectorizer = TfidfVectorizer(stop_words='english', max_features=1000)
X = vectorizer.fit_transform(df['DescriptionProcessed'])
```

```
[33]: X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.3, random_state=42)
```

Random Forest Classifier

```
[34]: rfc = MultiOutputClassifier(RandomForestClassifier(random_state=42))
```

```
[35]: rfc.fit(X_train, Y_train)
```

```
[35]: MultiOutputClassifier(estimator=RandomForestClassifier(random_state=42))
```

1.3.6 MLP Classifier

```
[36]: mlp = MultiOutputClassifier(MLPClassifier(max_iter=300, random_state=42))
```

```
[37]: mlp.fit(X_train, Y_train)
```

```
[37]: MultiOutputClassifier(estimator=MLPClassifier(max_iter=300, random_state=42))
```

1.3.7 Decision Tree Classifier

```
[38]: dtc = MultiOutputClassifier(DecisionTreeClassifier(random_state=42))
```

```
[39]: dtc.fit(X_train, Y_train)
```

```
[39]: MultiOutputClassifier(estimator=DecisionTreeClassifier(random_state=42))
```

1.3.8 Keras Neural Network

```
[40]: model_k = create_model()
```

```
[41]: X_train_dense = X_train.toarray() if 'toarray' in dir(X_train) else X_train  
Y_train_dense = Y_train.toarray() if 'toarray' in dir(Y_train) else Y_train
```

```
[42]: model_k.fit(X_train_dense, Y_train_dense, epochs=10, batch_size=32)
```

```
Epoch 1/10  
193/193          2s 4ms/step -  
accuracy: 0.0197 - loss: 0.5249  
Epoch 2/10  
193/193          1s 4ms/step -  
accuracy: 0.0199 - loss: 0.1753  
Epoch 3/10  
193/193          1s 4ms/step -  
accuracy: 0.0854 - loss: 0.1668  
Epoch 4/10  
193/193          1s 4ms/step -  
accuracy: 0.1073 - loss: 0.1599  
Epoch 5/10  
193/193          1s 5ms/step -  
accuracy: 0.2185 - loss: 0.1509  
Epoch 6/10  
193/193          1s 5ms/step -  
accuracy: 0.2604 - loss: 0.1442  
Epoch 7/10  
193/193          1s 4ms/step -
```

```
accuracy: 0.3210 - loss: 0.1376
Epoch 8/10
193/193          1s 4ms/step -
accuracy: 0.3247 - loss: 0.1320
Epoch 9/10
193/193          1s 3ms/step -
accuracy: 0.3655 - loss: 0.1280
Epoch 10/10
193/193          1s 3ms/step -
accuracy: 0.3841 - loss: 0.1238
```

[42]: <keras.src.callbacks.history.History at 0x1d6614be1d0>

1.3.9 Performance Comparsion

[43]: X_test_dense = X_test.toarray() if 'toarray' in dir(X_test) else X_test

[44]: rfc_metrics = evaluate_model(rfc, X_test, Y_test)

[45]: mlp_metrics = evaluate_model(mlp, X_test, Y_test)

[46]: dtc_metrics = evaluate_model(dtc, X_test, Y_test)

[47]: keras_model_metrics = evaluate_model(model_k, X_test_dense, Y_test, model_type='keras')

83/83 0s 3ms/step

[48]: print(f"Random Forest Metrics: {rfc_metrics}")

```
Random Forest Metrics: {'Accuracy': 0.04161937192584184, 'Recall': 0.10302506482281763, 'Precision': 0.587192118226601, 'F1-Score': 0.17529411764705882, 'Hamming Loss': 0.05051979172296993}
```

[49]: print(f"Neural Network Metrics: {mlp_metrics}")

```
Neural Network Metrics: {'Accuracy': 0.07756337495270525, 'Recall': 0.28349178910976663, 'Precision': 0.3930026359932902, 'F1-Score': 0.3293834103233581, 'Hamming Loss': 0.060158910329171394}
```

[50]: print(f"Decision Tree Metrics: {dtc_metrics}")

```
Decision Tree Metrics: {'Accuracy': 0.03594400302686341, 'Recall': 0.25324114088159033, 'Precision': 0.2961390741863756, 'F1-Score': 0.27301528140141634, 'Hamming Loss': 0.07028448912671387}
```

[51]: print(f"Keras Neural Network Metrics: {keras_model_metrics}")

```
Keras Neural Network Metrics: {'Accuracy': 0.06848278471433976, 'Recall': 0.1662921348314607, 'Precision': 0.5719381688466112, 'F1-Score': 0.25766706843444487, 'Hamming Loss': 0.049934237788948344}
```

```
[52]: metrics_names = ['Accuracy', 'Recall', 'Precision', 'F1-Score', 'Hamming Loss']
models_metrics = [rfc_metrics, mlp_metrics, dtc_metrics, keras_model_metrics]
models_names = ['Random Forest', 'MLP', 'Decision Tree', 'Keras Model']

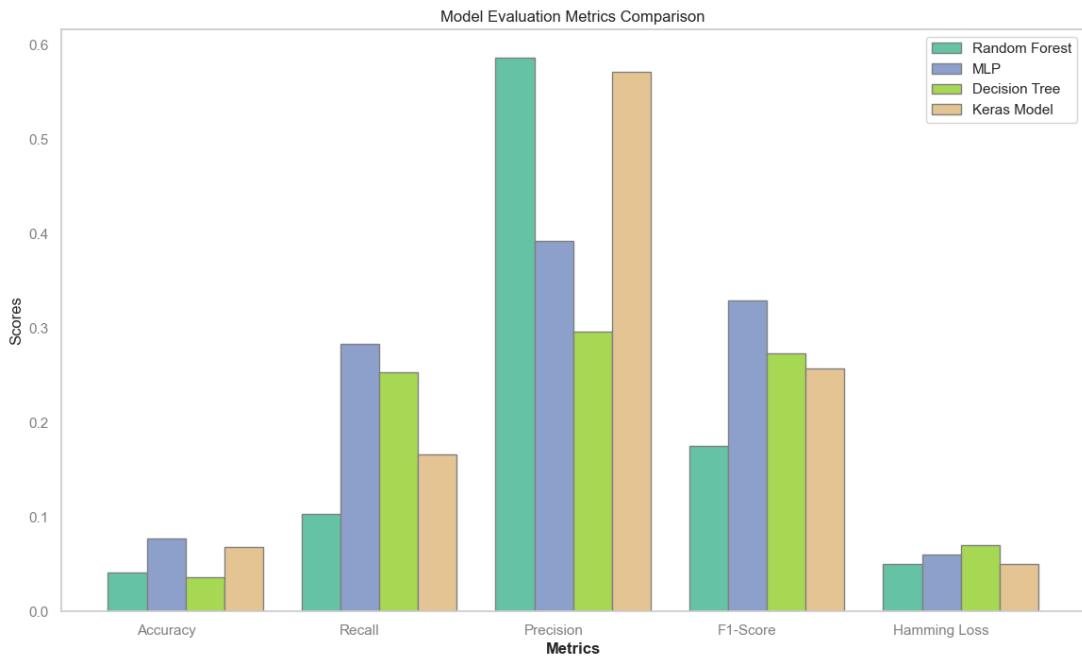
data = np.array([[model[metric] for metric in metrics_names] for model in models_metrics])

n = len(metrics_names)
r = np.arange(n)
barWidth = 0.2

fig, ax = plt.subplots(figsize=(14, 8))
for i in range(len(models_names)):
    ax.bar(r + i * barWidth, data[i], color=plt.cm.Set2(i / float(len(models_names))), width=barWidth, edgecolor='grey', label=models_names[i])

ax.set_xlabel('Metrics', fontweight='bold')
ax.set_xticks([r + barWidth for r in range(len(metrics_names))])
ax.set_xticklabels(metrics_names)

plt.legend()
plt.title('Model Evaluation Metrics Comparison')
plt.ylabel('Scores')
plt.grid(False, axis='y', linestyle='--', alpha=0.7)
plt.grid(False)
fig.savefig('plot1.pdf')
plt.show()
```



1.3.10 Cross-Validation

```
[53]: model_names = ['RandomForest', 'MLP', 'DecisionTree', 'Keras Sequential']

[54]: mean_accuracies = []
std_accuracies = []
hamming_losses = []

[55]: mean, std, hs = cross_validate_multilabel_model(rfc, X, Y, model_type='sklearn')

[56]: print('RFC Metrcis', 'Mean:', str(mean), 'STD:', str(std), 'Hamming Loss:', str(hs))
```

RFC Metrcis Mean: 0.05189053273698452 STD: 0.006182300376716887 Hamming Loss:
0.050046767581143695

```
[57]: mean_accuracies.append(mean)
std_accuracies.append(std)
hamming_losses.append(hs)

[58]: mean, std, hs = cross_validate_multilabel_model(mlp, X, Y, model_type='sklearn')

[59]: mean_accuracies.append(mean)
std_accuracies.append(std)
hamming_losses.append(hs)
```

```
[60]: print('MLP Metrcis', 'Mean:', str(mean), 'STD:', str(std), 'Hamming Loss:',  
        str(hs))
```

```
MLP Metrcis Mean: 0.08436588951819632 STD: 0.006383729938445133 Hamming Loss:  
0.05924127188545236
```

```
[61]: mean, std, hs = cross_validate_multilabel_model(dtc, X, Y, model_type='sklearn')
```

```
[62]: mean_accuracies.append(mean)  
std_accuracies.append(std)  
hamming_losses.append(hs)
```

```
[63]: print('DTC Metrcis', 'Mean:', str(mean), 'STD:', str(std), 'Hamming Loss:',  
        str(hs))
```

```
DTC Metrcis Mean: 0.04405530084611661 STD: 0.002899389251090463 Hamming Loss:  
0.07031478814733866
```

```
[64]: mean, std, hs = cross_validate_multilabel_model(model_k, X, Y,  
        model_type='keras')
```

```
56/56          0s 3ms/step  
56/56          0s 2ms/step  
56/56          0s 2ms/step  
56/56          0s 2ms/step  
56/56          0s 3ms/step
```

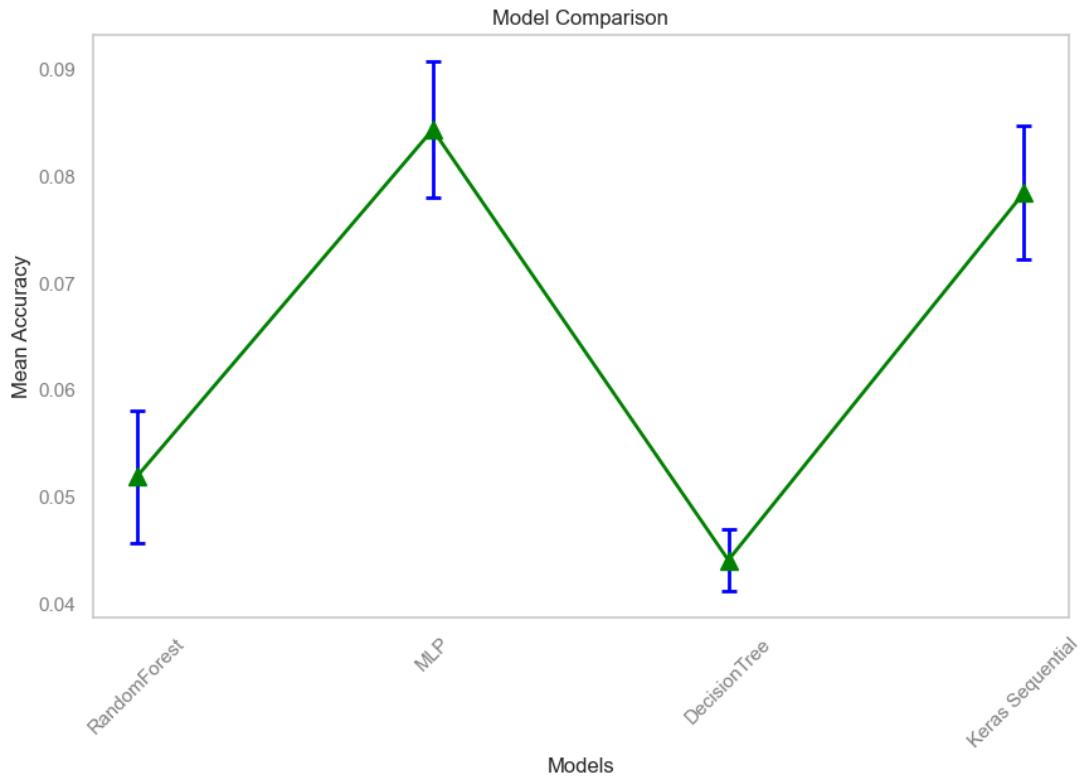
```
[65]: mean_accuracies.append(mean)  
std_accuracies.append(std)  
hamming_losses.append(hs)
```

```
[66]: print('Keras Model Metrcis', 'Mean:', str(mean), 'STD:', str(std), 'Hamming  
Loss:', str(hs))
```

```
Keras Model Metrcis Mean: 0.07846099207124216 STD: 0.006220550946438165 Hamming  
Loss: 0.04924102204092226
```

```
[67]: plt.figure(figsize=(10, 6))  
plt.errorbar(model_names, mean_accuracies, yerr=std_accuracies, fmt='^-o',  
             capsize=4, capthick=2, ecolor='blue', linestyle='--', marker='^',  
             markersize=10, linewidth=2,color='green')  
plt.title('Model Comparison')  
plt.ylabel('Mean Accuracy')  
plt.xlabel('Models')  
plt.xticks(rotation=45)  
plt.grid(True, which='both', linestyle='--', linewidth=0.5)  
plt.grid(False)  
fig.savefig('plot2.pdf')
```

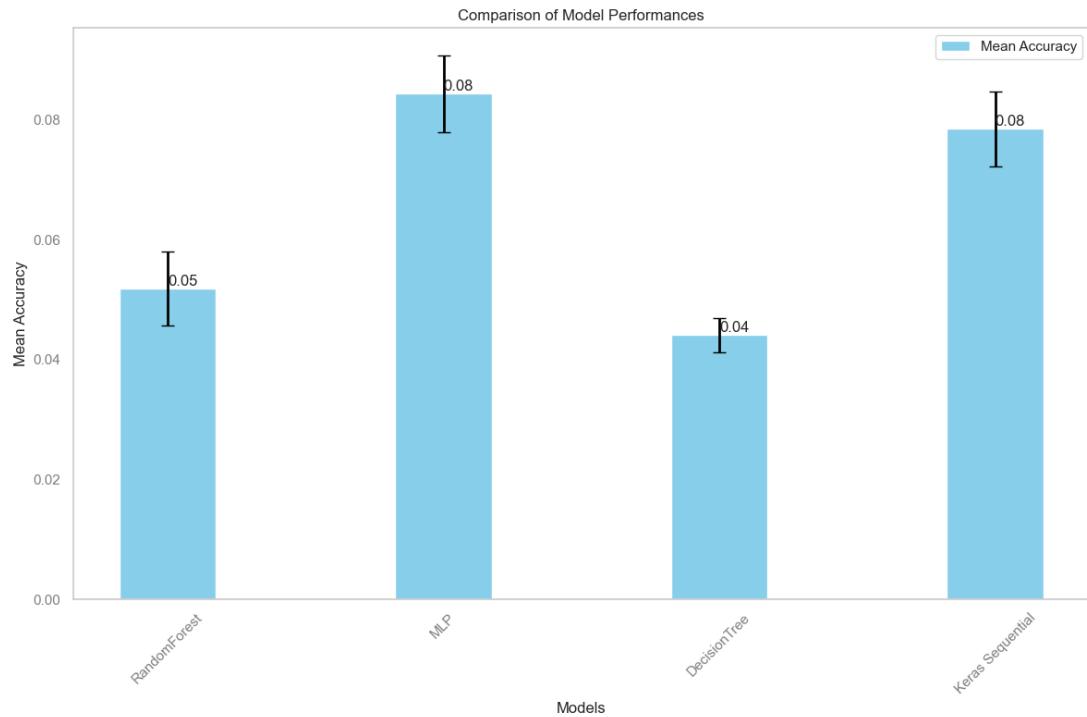
```
plt.show()
```



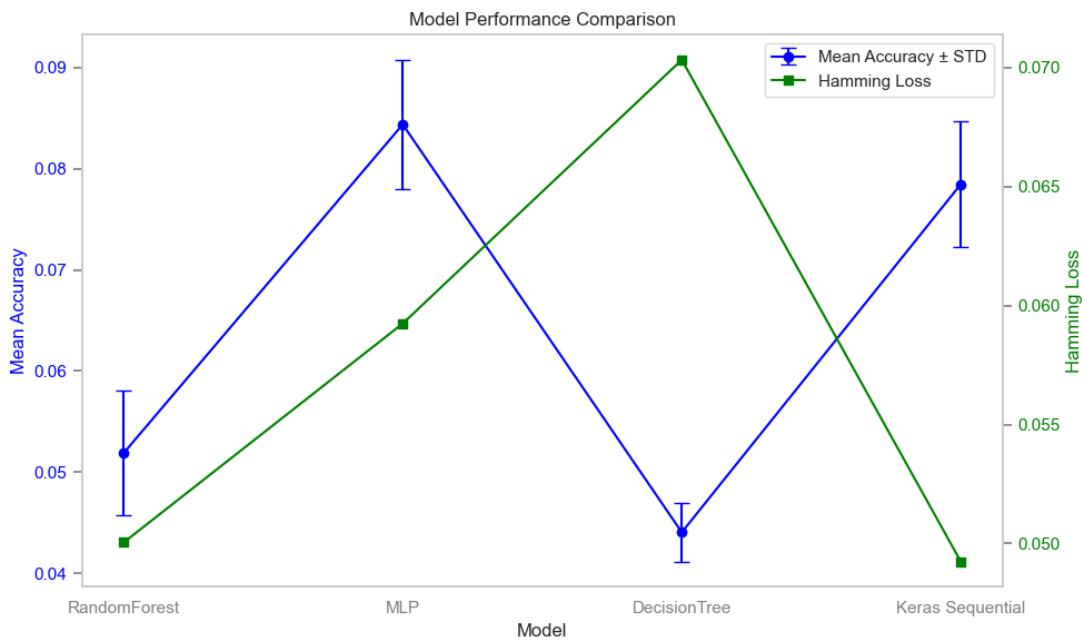
```
[68]: plt.figure(figsize=(12, 8))
bar_positions = np.arange(len(model_names))
bar_width = 0.35
error_attr = dict(elinewidth=2, ecolor='black', capsize=5)
bars = plt.bar(bar_positions, mean_accuracies, bar_width, color='skyblue', □
    ↪label='Mean Accuracy', yerr=std_accuracies, error_kw=error_attr)
plt.xlabel('Models')
plt.ylabel('Mean Accuracy')
plt.title('Comparison of Model Performances')
plt.xticks(bar_positions, model_names, rotation=45)
plt.legend()
for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2.0, yval, round(yval, 2), □
        ↪va='bottom') # va: vertical alignment

plt.grid(True, which='both', linestyle='--', linewidth=0.5, axis='y')
plt.tight_layout()
plt.grid(False)
```

```
fig.savefig('plot3.pdf')
plt.show()
```



```
[69]: fig, ax1 = plt.subplots(figsize=(10, 6))
ax1.errorbar(model_names, mean_accuracies, yerr=std_accuracies, fmt='^-o', u
             capsize=5, label='Mean Accuracy ± STD', color='blue')
ax1.set_xlabel('Model')
ax1.set_ylabel('Mean Accuracy', color='blue')
ax1.tick_params(axis='y', labelcolor='blue')
ax1.grid(False)
ax2 = ax1.twinx()
ax2.plot(model_names, hamming_losses, '-s', label='Hamming Loss', color='green')
ax2.set_ylabel('Hamming Loss', color='green')
ax2.tick_params(axis='y', labelcolor='green')
ax2.grid(False)
plt.title('Model Performance Comparison')
fig.tight_layout()
fig.legend(loc="upper right", bbox_to_anchor=(1,1), bbox_transform=ax1.
           transAxes)
fig.savefig('plot20.pdf')
plt.show()
```

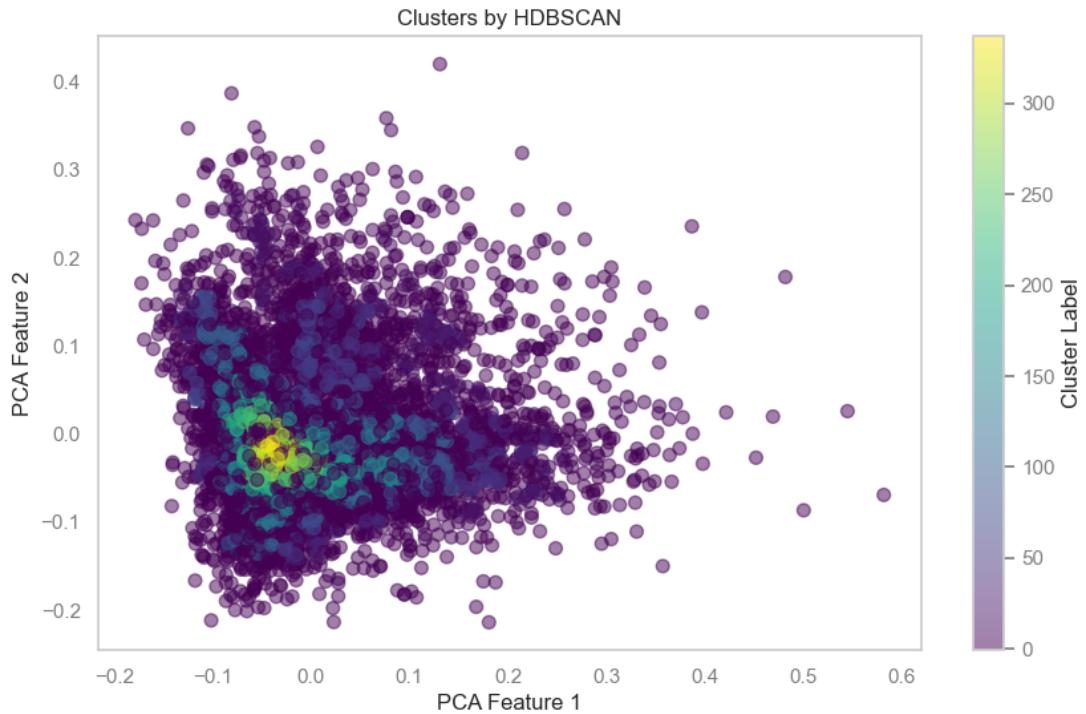


1.3.11 Visualization and Clustering

```
[70]: X_dense = X.toarray()

pca = PCA(n_components=2)
X_pca = pca.fit_transform(X_dense)

hdbSCAN_cluster = HDBSCAN(min_cluster_size=5, gen_min_span_tree=True)
clusters = hdbSCAN_cluster.fit_predict(X_pca)
plt.figure(figsize=(10, 6))
plt.scatter(X_pca[:, 0], X_pca[:, 1], c=clusters, cmap='viridis', s=50, alpha=0.5)
plt.colorbar(label='Cluster Label')
plt.title('Clusters by HDBSCAN')
plt.xlabel('PCA Feature 1')
plt.ylabel('PCA Feature 2')
plt.grid(False)
fig.savefig('plot4.pdf')
plt.show()
```



```
[71]: num_features = X.shape[1]

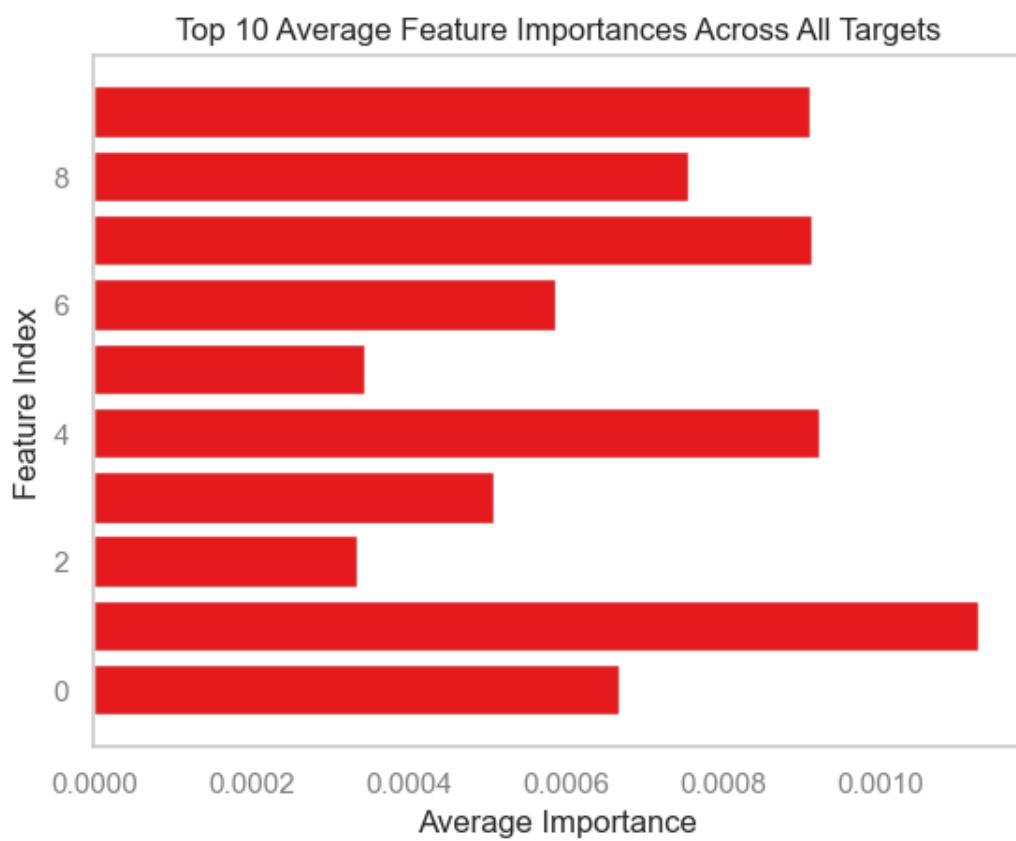
aggregate_feature_importances = np.zeros(num_features)

for estimator in rfc.estimators_:
    aggregate_feature_importances += estimator.feature_importances_

aggregate_feature_importances /= len(rfc.estimators_)

feature_indices = np.arange(num_features)

plt.barh(feature_indices[:10], aggregate_feature_importances[:10])
plt.xlabel('Average Importance')
plt.ylabel('Feature Index')
plt.title('Top 10 Average Feature Importances Across All Targets')
plt.grid(False)
fig.savefig('plot5.pdf')
plt.show()
```



ProjectGroup-6-V2GrapKmeansExtension

March 10, 2024

1 NETFLIX DATA DRIVEN PRODUCT RECCOMENDATION

1.1 Group 6 Project Assignment

- Donato Scarano
- Jacob Yousif
- Yuehua Qin

As an integration to the original code and to expand the analysis on the basis of what we discussed during the presentation we have implemented a Reccomender System where given a movie and based on the features of the movie such as actor, director, country, listed_in we reccomend a list of related movies and we visualize the relationships in a graph format.

1.1.1 Import Packages

```
[28]: import warnings  
warnings.filterwarnings('ignore')
```

```
[29]: %%capture  
!pip install pandas_profiling  
!pip install pydantic-settings  
!pip install bump-pydantic  
!pip install -U pydantic  
!pip install AutoViz  
!pip install hdbscan  
!pip install --upgrade tensorflow
```

```
[30]: %%capture  
import numpy as np  
import pandas as pd  
import matplotlib.pyplot as plt  
import seaborn as sns  
import math as math  
from autoviz.AutoViz_Class import AutoViz_Class  
from sklearn.feature_extraction.text import TfidfVectorizer  
from sklearn.decomposition import PCA  
from sklearn.model_selection import cross_val_score  
from sklearn.neural_network import MLPClassifier
```

```

from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import MultiLabelBinarizer
from sklearn.multioutput import MultiOutputClassifier
from sklearn.tree import DecisionTreeClassifier, plot_tree
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, recall_score, precision_score, f1_score, hamming_loss, make_scorer
from sklearn.inspection import permutation_importance
from sklearn.model_selection import KFold
from sklearn.base import clone
from sklearn.multiclass import OneVsRestClassifier
from hdbscan import HDBSCAN
from keras.models import Sequential
from keras.layers import Dense
from sklearn.model_selection import cross_val_score, StratifiedKFold
import nltk
from nltk.stem.porter import PorterStemmer
import spacy
from scipy.sparse import csr_matrix
nlp = spacy.load('en_core_web_sm')
nltk.download('stopwords', quiet=True)
nltk.download('punkt', quiet=True)
%matplotlib inline

```

1.1.2 Import Dataset

[85]: df = pd.read_csv('netflix_titles.csv')

1.1.3 Preprocess the data

[72]: autoviz = AutoViz_Class().AutoViz('netflix_titles.csv')

```

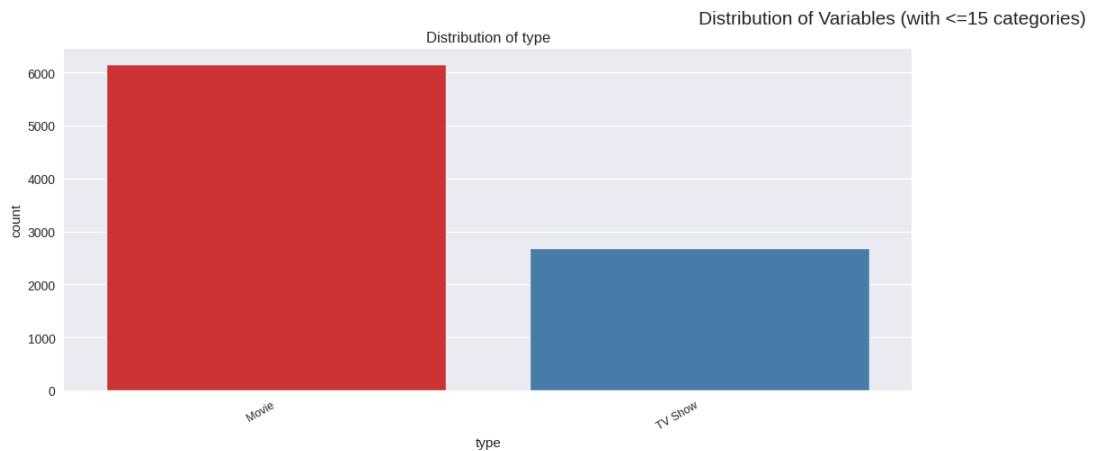
Shape of your Data Set loaded: (8807, 12)
#####
##### C L A S S I F Y I N G   V A R I A B L E S
#####
Classifying variables in data set...
    Number of Numeric Columns =  0
    Number of Integer-Categorical Columns =  0
    Number of String-Categorical Columns =  1
    Number of Factor-Categorical Columns =  0
    Number of String-Boolean Columns =  1
    Number of Numeric-Boolean Columns =  0
    Number of Discrete String Columns =  3

```

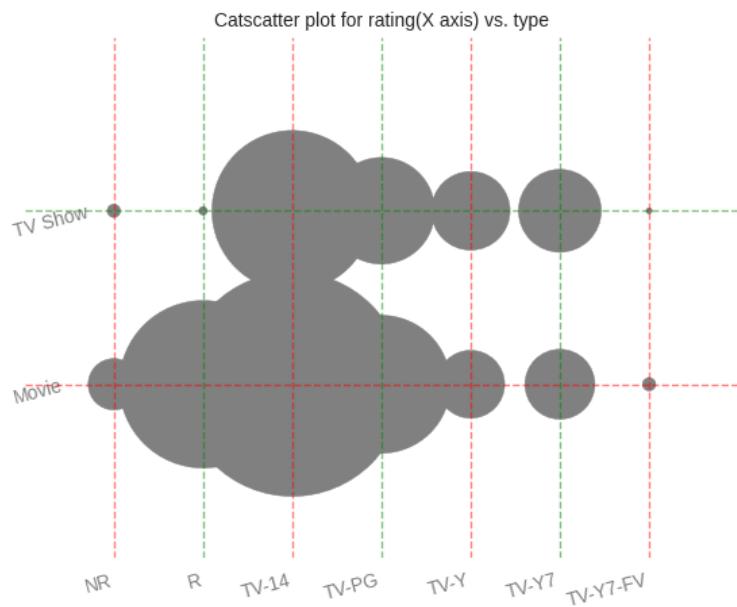
```
Number of NLP String Columns = 5
Number of Date Time Columns = 1
Number of ID Columns = 1
Number of Columns to Delete = 0
12 Predictors classified...
    1 variable(s) removed since they were ID or low-information variables
    List of variables removed: ['show_id']
To fix these data quality issues in the dataset, import FixDQ from autoviz...
    All variables classified into correct types.

<pandas.io.formats.style.Styler at 0x7ad8177910f0>
```

Could not draw Distribution Plot

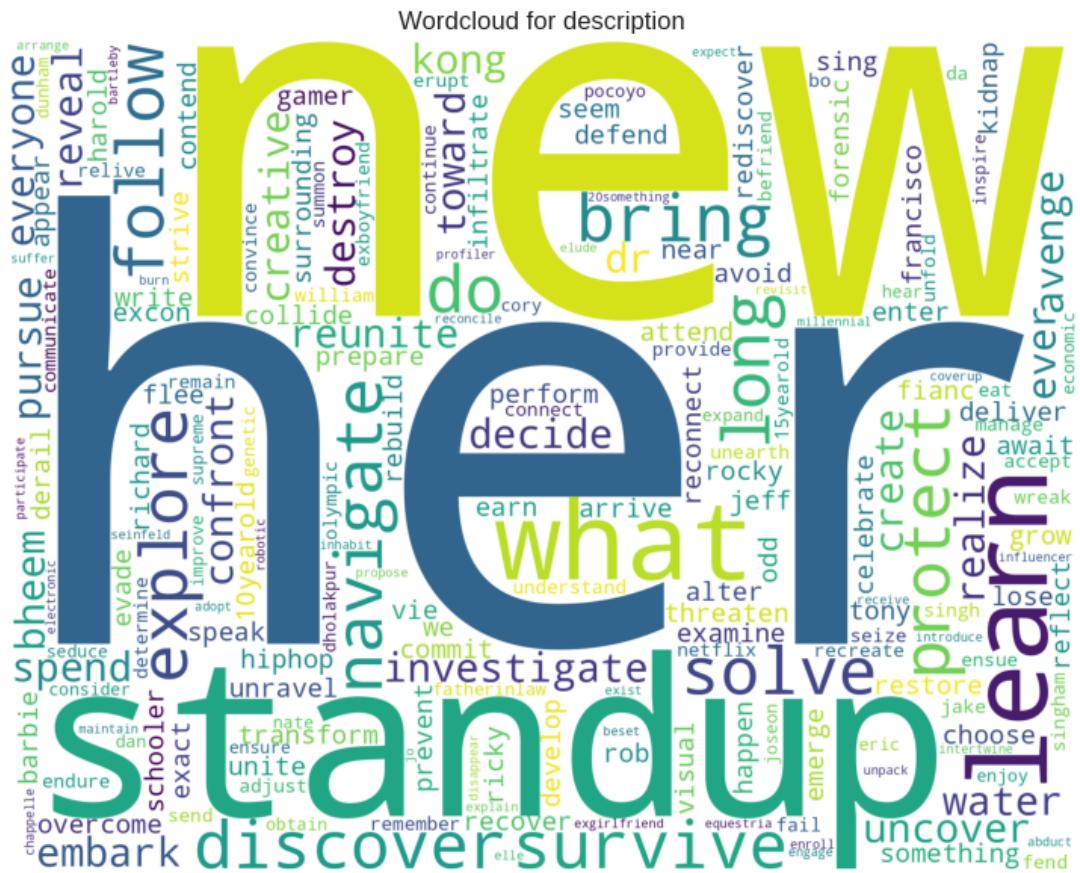


Catscatter plot of Pairs of Categorical Variables



Wordcloud for title





Wordcloud for director



Wordcloud for cast



Wordcloud for date_added

A wordcloud visualization where the size and color of each word represent its frequency. The words are mostly months of the year, with some variations in spelling and color. The most prominent words are 'december' (large green), 'july' (large green), 'september' (large teal), and 'missing' (small blue). Other visible words include 'april' (purple), 'march' (green), 'october' (teal), 'june' (green), 'may' (green), 'january' (green), 'august' (purple), 'february' (purple), and 'november' (green).

april march
december missing october
july june may
august january
september february november

Wordcloud for country



Wordcloud for duration

min
season
missing



All Plots done

Time to run AutoViz = 75 seconds

AUTO VISUALIZATION Completed

```
[86]: df.shape
```

[86]: (8807, 12)

```
[87]: df.head()
```

[87]: show id

id	show_id	type	title	director
0	s1	Movie	Dick Johnson Is Dead	Kirsten Johnson
1	s2	TV Show	Blood & Water	NaN
2	s3	TV Show	Ganglands	Julien Leclercq
3	s4	TV Show	Jailbirds New Orleans	NaN
4	s5	TV Show	Kota Factory	NaN

cast

```
\n0\nNaN\n1 Ama Qamata, Khosi Ngema, Gail Mabalane, Thabang Molaba, Dillon Windvogel,\nNatasha Thahane, Arno Greeff, Xolile Tshabalala, Getmore Sithole, Cindy\nMahlangu, Ryle De Morny, Greteli Fincham, Sello Maake Ka-Ncube, Odwa Gwanya,\nMekaila Mathys, Sandi Schultz, Duane Williams, Shamilla Miller, Patrick Mofokeng\n2
```

```
Sami Bouajila, Tracy Gotoas, Samuel Jouy, Nabiha Akkari, Sofia Lesaffre, Salim\nKechiouche, Noureddine Farihi, Geert Van Rampelberg, Bakary Diombera
```

```
3
```

```
NaN
```

```
4
```

```
Mayur More, Jitendra Kumar, Ranjan Raj, Alam Khan, Ahsaas Channa, Revathi\nPillai, Urvi Singh, Arun Kumar
```

```
country      date_added    release_year rating duration  \
0 United States September 25, 2021 2020 PG-13 90 min
1 South Africa September 24, 2021 2021 TV-MA 2 Seasons
2           NaN September 24, 2021 2021 TV-MA 1 Season
3           NaN September 24, 2021 2021 TV-MA 1 Season
4           India September 24, 2021 2021 TV-MA 2 Seasons
```

```
listed_in          \
0                  Documentaries
1          International TV Shows, TV Dramas, TV Mysteries
2          Crime TV Shows, International TV Shows, TV Action & Adventure
3                      Docuseries, Reality TV
4          International TV Shows, Romantic TV Shows, TV Comedies
```

```
description
```

```
0 As her father nears the end of his life, filmmaker Kirsten Johnson stages his\ndeath in inventive and comical ways to help them both face the inevitable.
```

```
1 After crossing paths at a party, a Cape Town teen sets out to prove\nwhether a private-school swimming star is her sister who was abducted at birth.
```

```
2 To protect his family from a powerful drug lord, skilled thief Mehdi\nand his expert team of robbers are pulled into a violent and deadly turf war.
```

```
3 Feuds, flirtations and toilet talk go down among the incarcerated women\nat the Orleans Justice Center in New Orleans on this gritty reality series.
```

```
4 In a city of coaching centers known to train India's finest collegiate minds,\nan earnest but unexceptional student and his friends navigate campus life.
```

```
[88]: df.isnull().sum()
```

```
[88]: show_id      0
type          0
title         0
```

```
director      2634
cast          825
country       831
date_added    10
release_year   0
rating         4
duration       3
listed_in      0
description     0
dtype: int64
```

```
[89]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8807 entries, 0 to 8806
Data columns (total 12 columns):
 #   Column      Non-Null Count  Dtype  
 ---  --          -----          ----  
 0   show_id     8807 non-null   object 
 1   type        8807 non-null   object 
 2   title       8807 non-null   object 
 3   director    6173 non-null   object 
 4   cast         7982 non-null   object 
 5   country     7976 non-null   object 
 6   date_added  8797 non-null   object 
 7   release_year 8807 non-null   int64  
 8   rating       8803 non-null   object 
 9   duration     8804 non-null   object 
 10  listed_in    8807 non-null   object 
 11  description   8807 non-null   object 
dtypes: int64(1), object(11)
memory usage: 825.8+ KB
```

Kmeans Clustering with TF-IDF Weights

```
[92]: #We use KMeans clustering with TF-IDF weights
```

```
# import librairies
import networkx as nx
import math as math
import time
plt.style.use('seaborn')
plt.rcParams['figure.figsize'] = [14,14]
```

```
[93]: # convert to datetime
df["date_added"] = pd.to_datetime(df['date_added'])
df['year'] = df['date_added'].dt.year
df['month'] = df['date_added'].dt.month
```

```

df['day'] = df['date_added'].dt.day
# convert columns "director, listed_in, cast and country" in columns that
# contain a real list
# the strip function is applied on the elements
# if the value is NaN, the new column contains a empty list []
df['directors'] = df['director'].apply(lambda l: [] if pd.isna(l) else [i.
    strip() for i in l.split(",")])
df['categories'] = df['listed_in'].apply(lambda l: [] if pd.isna(l) else [i.
    strip() for i in l.split(",")])
df['actors'] = df['cast'].apply(lambda l: [] if pd.isna(l) else [i.strip() for
    i in l.split(",")])
df['countries'] = df['country'].apply(lambda l: [] if pd.isna(l) else [i.
    strip() for i in l.split(",")])

df.head()

```

```

[93]:   show_id  type          title      director      \
0     s1      Movie  Dick Johnson Is Dead  Kirsten Johnson
1     s2      TV Show        Blood & Water           NaN
2     s3      TV Show          Ganglands  Julien Leclercq
3     s4      TV Show  Jailbirds New Orleans           NaN
4     s5      TV Show          Kota Factory           NaN

                                         cast
\
0
NaN
1  Ama Qamata, Khosi Ngema, Gail Mabalane, Thabang Molaba, Dillon Windvogel,
Natasha Thahane, Arno Greeff, Xolile Tshabalala, Getmore Sithole, Cindy
Mahlangu, Ryle De Morny, Greteli Fincham, Sello Maake Ka-Ncube, Odwa Gwanya,
Mekaila Mathys, Sandi Schultz, Duane Williams, Shamilla Miller, Patrick Mofokeng
2
Sami Bouajila, Tracy Gotoas, Samuel Jouy, Nabiha Akkari, Sofia Lesaffre, Salim
Kechiouche, Noureddine Farihi, Geert Van Rampelberg, Bakary Diombera
3
NaN
4
Mayur More, Jitendra Kumar, Ranjan Raj, Alam Khan, Ahsaas Channa, Revathi
Pillai, Urvi Singh, Arun Kumar

      country  date_added  release_year rating duration      \
0  United States  2021-09-25      2020    PG-13    90 min
1  South Africa  2021-09-24      2021    TV-MA  2 Seasons
2            NaN  2021-09-24      2021    TV-MA   1 Season
3            NaN  2021-09-24      2021    TV-MA   1 Season
4            India  2021-09-24      2021    TV-MA  2 Seasons

```

```

        listed_in           \
0          Documentaries
1          International TV Shows, TV Dramas, TV Mysteries
2  Crime TV Shows, International TV Shows, TV Action & Adventure
3          Docuseries, Reality TV
4          International TV Shows, Romantic TV Shows, TV Comedies

description
\
0  As her father nears the end of his life, filmmaker Kirsten Johnson stages his
death in inventive and comical ways to help them both face the inevitable.
1  After crossing paths at a party, a Cape Town teen sets out to prove
whether a private-school swimming star is her sister who was abducted at birth.
2  To protect his family from a powerful drug lord, skilled thief Mehdi
and his expert team of robbers are pulled into a violent and deadly turf war.
3  Feuds, flirtations and toilet talk go down among the incarcerated women
at the Orleans Justice Center in New Orleans on this gritty reality series.
4  In a city of coaching centers known to train India's finest collegiate minds,
an earnest but unexceptional student and his friends navigate campus life.

      year    month    day    directors      \
0  2021.0    9.0    25.0  [Kirsten Johnson]
1  2021.0    9.0    24.0          []
2  2021.0    9.0    24.0  [Julien Leclercq]
3  2021.0    9.0    24.0          []
4  2021.0    9.0    24.0          []

categories           \
0          [Documentaries]
1          [International TV Shows, TV Dramas, TV Mysteries]
2  [Crime TV Shows, International TV Shows, TV Action & Adventure]
3          [Docuseries, Reality TV]
4          [International TV Shows, Romantic TV Shows, TV Comedies]

actors
\
0
[]
1  [Ama Qamata, Khosi Ngema, Gail Mabalane, Thabang Molaba, Dillon Windvogel,
Natasha Thahane, Arno Greeff, Xolile Tshabalala, Getmore Sithole, Cindy
Mahlangu, Ryle De Morny, Greteli Fincham, Sello Maake Ka-Ncube, Odwa Gwanya,
Mekaila Mathys, Sandi Schultz, Duane Williams, Shamilla Miller, Patrick
Mofokeng]
2
[Sam Bouajila, Tracy Gotoas, Samuel Jouy, Nabiha Akkari, Sofia Lesaffre, Salim
Kechiouche, Noureddine Farihi, Geert Van Rampelberg, Bakary Diombera]
3

```

```
[]
4
[Mayur More, Jitendra Kumar, Ranjan Raj, Alam Khan, Ahsaas Channa, Revathi Pillai, Urvi Singh, Arun Kumar]

    countries
0  [United States]
1  [South Africa]
2  []
3  []
4  [India]
```

```
[94]: from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.metrics.pairwise import linear_kernel
from sklearn.cluster import MiniBatchKMeans

# Build the tfidf matrix with the descriptions
start_time = time.time()
text_content = df['description']
vector = TfidfVectorizer(max_df=0.4,                      # drop words that occur in more
                           ↪than X percent of documents
                           min_df=1,           # only use words that appear at
                           ↪least X times
                           stop_words='english', # remove stop words
                           lowercase=True,     # Convert everything to lower case
                           use_idf=True,       # Use idf
                           norm=u'l2',         # Normalization
                           smooth_idf=True)   # Prevents divide-by-zero errors
tfidf = vector.fit_transform(text_content)
```

```
[95]: # Clustering Kmeans

k = 200
kmeans = MiniBatchKMeans(n_clusters = k)
kmeans.fit(tfidf)
centers = kmeans.cluster_centers_.argsort()[:,::-1]
terms = vector.get_feature_names_out()

# print the centers of the clusters
# for i in range(0,k):
#     word_list=[]
#     print("cluster%d: "% i)
#     for j in centers[i,:10]:
#         word_list.append(terms[j])
#     print(word_list)

request_transform = vector.transform(df['description'])
```

```
# new column cluster based on the description
df['cluster'] = kmeans.predict(request_transform)

df['cluster'].value_counts().head()
```

[95]:

	129	7150
27	500	
177	468	
53	403	
91	90	

Name: cluster, dtype: int64

[96]:

```
# Find similar : get the top_n movies with description similar to the target
# description
def find_similar(tfidf_matrix, index, top_n = 5):
    cosine_similarities = linear_kernel(tfidf_matrix[index:index+1], tfidf_matrix).flatten()
    related_docs_indices = [i for i in cosine_similarities.argsort()[:-1] if i != index]
    return [index for index in related_docs_indices][0:top_n]
```

Create a graph (undirected graph)

Nodes are : Movies Person (actor or director) Categories Countries Cluster (description) Sim(title)
top 5 similar movies in the sense of the description

Edges are : ACTED_IN : relation between an actor and a movie CAT_IN : relation between a category and a movie DIRECTED : relation between a director and a movie COU_IN : relation between a country and a movie DESCRIPTION : relation between a cluster and a movie SIMILARITY in the sense of the description

Two movies are not directly connected, but they share persons, categories,clusters and countries

[97]:

```
G = nx.Graph(label="MOVIE")
start_time = time.time()
for i, rowi in df.iterrows():
    if (i%1000==0):
        print(" iter {} -- {} seconds --".format(i,time.time() - start_time))
    G.add_node(rowi['title'], key=rowi['show_id'], label="MOVIE", mtype=rowi.get('type', ''), rating=rowi.get('rating', ''))
    for element in rowi['actors']:
        G.add_node(element, label="PERSON")
        G.add_edge(rowi['title'], element, label="ACTED_IN")
    for element in rowi['categories']:
        G.add_node(element, label="CAT")
        G.add_edge(rowi['title'], element, label="CAT_IN")
    for element in rowi['directors']:
        G.add_node(element, label="PERSON")
```

```

        G.add_edge(rowi['title'], element, label="DIRECTED")
    for element in rowi['countries']:
        G.add_node(element, label="COU")
        G.add_edge(rowi['title'], element, label="COU_IN")

    indices = find_similar(tfidf, i, top_n=5)
    if len(indices) > 0: # Check if indices is not empty
        snode = "Sim(" + rowi['title'][:15].strip() + ")"
        G.add_node(snode, label="SIMILAR")
        G.add_edge(rowi['title'], snode, label="SIMILARITY")
        for element in indices:
            G.add_edge(snode, df['title'].iloc[element], label="SIMILARITY")
    print(" finish -- {} seconds --".format(time.time() - start_time))

def get_all_adj_nodes(list_in):
    sub_graph=set()
    for m in list_in:
        sub_graph.add(m)
        for e in G.neighbors(m):
            sub_graph.add(e)
    return list(sub_graph)
def draw_sub_graph(sub_graph):
    subgraph = G.subgraph(sub_graph)
    colors=[]
    for e in subgraph.nodes():
        if G.nodes[e]['label']=="MOVIE":
            colors.append('blue')
        elif G.nodes[e]['label']=="PERSON":
            colors.append('red')
        elif G.nodes[e]['label']=="CAT":
            colors.append('green')
        elif G.nodes[e]['label']=="COU":
            colors.append('yellow')
        elif G.nodes[e]['label']=="SIMILAR":
            colors.append('orange')
        elif G.nodes[e]['label']=="CLUSTER":
            colors.append('orange')

    nx.draw(subgraph, with_labels=True, font_weight='bold', node_color=colors)
    plt.show()

```

Streaming output truncated to the last 5000 lines.

```

finish -- 29.696244716644287 seconds --
finish -- 29.702306747436523 seconds --
finish -- 29.708182096481323 seconds --
finish -- 29.714118242263794 seconds --

```

```
finish -- 29.720061540603638 seconds --
finish -- 29.725634813308716 seconds --
finish -- 29.73117446899414 seconds --
finish -- 29.73663568496704 seconds --
finish -- 29.742292642593384 seconds --
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finish -- 29.759707927703857 seconds --
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finish -- 29.803730249404907 seconds --
finish -- 29.80917763710022 seconds --
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finish -- 29.82645845413208 seconds --
finish -- 29.832138776779175 seconds --
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finish -- 29.904989004135132 seconds --
finish -- 29.910428762435913 seconds --
finish -- 29.916175365447998 seconds --
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finish -- 29.929623126983643 seconds --
finish -- 29.937726497650146 seconds --
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finish -- 29.94883108139038 seconds --
finish -- 29.954292058944702 seconds --
finish -- 29.95975399017334 seconds --
finish -- 29.965336322784424 seconds --
finish -- 29.971352338790894 seconds --
finish -- 29.978779554367065 seconds --
finish -- 29.98491334915161 seconds --
finish -- 29.99044108390808 seconds --
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```

```
finish -- 30.003377437591553 seconds --
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```

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finish -- 30.329412937164307 seconds --
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```

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finish -- 31.6411612033844 seconds --
finish -- 31.64890217781067 seconds --
finish -- 31.65637731552124 seconds --
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finish -- 31.680974006652832 seconds --
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finish -- 31.767982482910156 seconds --
finish -- 31.77529215812683 seconds --
finish -- 31.782963514328003 seconds --
finish -- 31.791906595230103 seconds --
finish -- 31.799633979797363 seconds --
```

```
finish -- 31.807281255722046 seconds --
finish -- 31.814876794815063 seconds --
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finish -- 31.846266269683838 seconds --
finish -- 31.853734970092773 seconds --
finish -- 31.861424446105957 seconds --
finish -- 31.869332551956177 seconds --
finish -- 31.877097845077515 seconds --
finish -- 31.88528609275818 seconds --
finish -- 31.893213510513306 seconds --
finish -- 31.901059865951538 seconds --
finish -- 31.90912103652954 seconds --
finish -- 31.91698956489563 seconds --
finish -- 31.925102949142456 seconds --
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finish -- 40.26840925216675 seconds --
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finish -- 48.88956928253174 seconds --
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finish -- 48.90179967880249 seconds --
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finish -- 51.42820453643799 seconds --
finish -- 51.437384605407715 seconds --
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finish -- 51.45486617088318 seconds --
finish -- 51.461873054504395 seconds --
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finish -- 51.73762583732605 seconds --
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finish -- 52.1347119808197 seconds --
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finish -- 52.38715052604675 seconds --
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finish -- 52.52688956260681 seconds --
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finish -- 52.64793682098389 seconds --
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finish -- 52.66378831863403 seconds --
finish -- 52.67429232597351 seconds --
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finish -- 52.82496380805969 seconds --
finish -- 52.8308687210083 seconds --
finish -- 52.836827516555786 seconds --
finish -- 52.84269189834595 seconds --
finish -- 52.84881901741028 seconds --
finish -- 52.85466122627258 seconds --
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finish -- 52.904969215393066 seconds --
finish -- 52.911232709884644 seconds --
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finish -- 53.22852849960327 seconds --
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finish -- 55.24869227409363 seconds --
finish -- 55.25460648536682 seconds --
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finish -- 60.033597469329834 seconds --
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finish -- 60.087679386138916 seconds --
finish -- 60.09294295310974 seconds --
finish -- 60.09830594062805 seconds --
finish -- 60.10383868217468 seconds --
finish -- 60.109004497528076 seconds --
finish -- 60.11420202255249 seconds --
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finish -- 60.311622619628906 seconds --
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finish -- 60.34906768798828 seconds --
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finish -- 60.37568926811218 seconds --
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finish -- 60.651050329208374 seconds --
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finish -- 60.83270454406738 seconds --
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finish -- 60.84272623062134 seconds --
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finish -- 60.852991342544556 seconds --
finish -- 60.85858345031738 seconds --
finish -- 60.86433124542236 seconds --
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finish -- 60.94539999961853 seconds --
finish -- 60.957380294799805 seconds --
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finish -- 61.202239751815796 seconds --
finish -- 61.208698749542236 seconds --
```

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```

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finish -- 63.64685130119324 seconds --
finish -- 63.65840530395508 seconds --
finish -- 63.66449952125549 seconds --
```

```
finish -- 63.67015075683594 seconds --
finish -- 63.67638897895813 seconds --
finish -- 63.682414293289185 seconds --
finish -- 63.68822383880615 seconds --
finish -- 63.69396257400513 seconds --
finish -- 63.69974327087402 seconds --
finish -- 63.70529890060425 seconds --
finish -- 63.71082067489624 seconds --
finish -- 63.71623349189758 seconds --
finish -- 63.72171950340271 seconds --
finish -- 63.72722578048706 seconds --
finish -- 63.73271918296814 seconds --
finish -- 63.73823022842407 seconds --
finish -- 63.74404978752136 seconds --
finish -- 63.74957537651062 seconds --
finish -- 63.75525999069214 seconds --
finish -- 63.76191759109497 seconds --
finish -- 63.768519163131714 seconds --
finish -- 63.77441620826721 seconds --
finish -- 63.78011441230774 seconds --
finish -- 63.78544521331787 seconds --
finish -- 63.79090070724487 seconds --
finish -- 63.798173904418945 seconds --
finish -- 63.80385947227478 seconds --
finish -- 63.811296701431274 seconds --
finish -- 63.81707787513733 seconds --
finish -- 63.82275724411011 seconds --
finish -- 63.82843780517578 seconds --
finish -- 63.833874225616455 seconds --
finish -- 63.83950591087341 seconds --
finish -- 63.8516902923584 seconds --
finish -- 63.85848546028137 seconds --
finish -- 63.8647518157959 seconds --
finish -- 63.87072777748108 seconds --
finish -- 63.87644577026367 seconds --
finish -- 63.8823447227478 seconds --
finish -- 63.88809633255005 seconds --
finish -- 63.89353013038635 seconds --
finish -- 63.89910936355591 seconds --
finish -- 63.9048547744751 seconds --
finish -- 63.91023778915405 seconds --
finish -- 63.91598176956177 seconds --
finish -- 63.92186260223389 seconds --
finish -- 63.927700996398926 seconds --
finish -- 63.933512687683105 seconds --
finish -- 63.93958044052124 seconds --
finish -- 63.94562792778015 seconds --
finish -- 63.95172834396362 seconds --
```

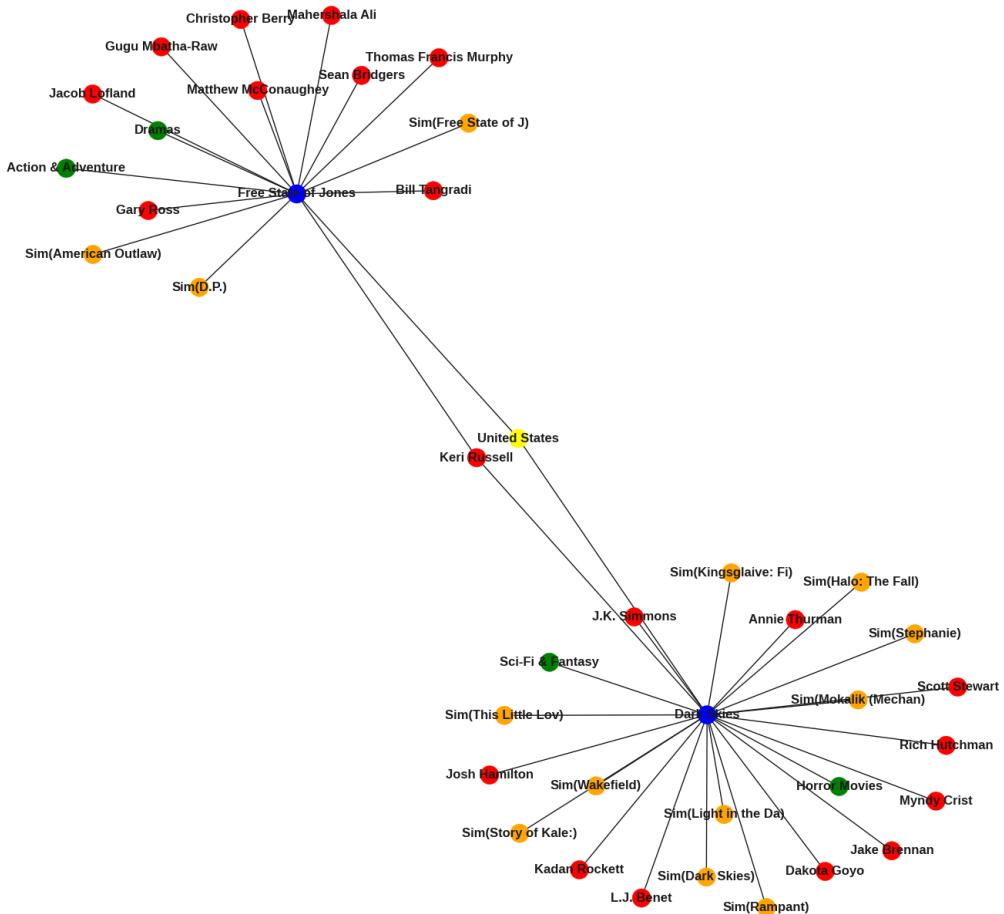
```
finish -- 63.95767903327942 seconds --
finish -- 63.96333026885986 seconds --
finish -- 63.969326972961426 seconds --
finish -- 63.97512149810791 seconds --
finish -- 63.981149435043335 seconds --
finish -- 63.98736047744751 seconds --
finish -- 63.993205070495605 seconds --
finish -- 63.99902033805847 seconds --
finish -- 64.00480484962463 seconds --
finish -- 64.01037669181824 seconds --
finish -- 64.01592111587524 seconds --
finish -- 64.0216817855835 seconds --
finish -- 64.02734088897705 seconds --
finish -- 64.03396773338318 seconds --
finish -- 64.03988218307495 seconds --
finish -- 64.04540038108826 seconds --
finish -- 64.05104279518127 seconds --
finish -- 64.0597710609436 seconds --
finish -- 64.06843852996826 seconds --
finish -- 64.07467317581177 seconds --
finish -- 64.08065509796143 seconds --
finish -- 64.08646631240845 seconds --
finish -- 64.09238481521606 seconds --
finish -- 64.09823536872864 seconds --
finish -- 64.10438323020935 seconds --
finish -- 64.11040759086609 seconds --
finish -- 64.11637449264526 seconds --
finish -- 64.12218594551086 seconds --
finish -- 64.12790107727051 seconds --
finish -- 64.13403844833374 seconds --
finish -- 64.14161682128906 seconds --
finish -- 64.14799761772156 seconds --
finish -- 64.15709733963013 seconds --
finish -- 64.16392111778259 seconds --
finish -- 64.16942143440247 seconds --
finish -- 64.17482376098633 seconds --
finish -- 64.18067646026611 seconds --
finish -- 64.18596506118774 seconds --
finish -- 64.19140553474426 seconds --
finish -- 64.19712018966675 seconds --
finish -- 64.20253157615662 seconds --
finish -- 64.20787978172302 seconds --
finish -- 64.21280765533447 seconds --
finish -- 64.21776676177979 seconds --
finish -- 64.22293734550476 seconds --
finish -- 64.22816562652588 seconds --
finish -- 64.233633518219 seconds --
finish -- 64.23947095870972 seconds --
```

```

finish -- 64.24489688873291 seconds --
finish -- 64.25181126594543 seconds --
finish -- 64.25759077072144 seconds --
finish -- 64.26739549636841 seconds --

```

```
[98]: list_in=["Free State of Jones","Dark Skies"]
sub_graph = get_all_adj_nodes(list_in)
draw_sub_graph(sub_graph)
```



Reccomendation Function

```
[99]: def get_recommendation(root):
    commons_dict = {}
    for e in G.neighbors(root):
```

```

        for e2 in G.neighbors(e):
            if e2 == root:
                continue
            if 'label' in G.nodes[e2] and G.nodes[e2]['label'] == "MOVIE":
                commons = commons_dict.get(e2)
                if commons is None:
                    commons_dict.update({e2: [e]})
                else:
                    commons.append(e)
                    commons_dict.update({e2: commons})
        movies = []
        weight = []
        for key, values in commons_dict.items():
            w = 0.0
            for e in values:
                w = w + 1 / math.log(G.degree(e))
            movies.append(key)
            weight.append(w)

        result = pd.Series(data=np.array(weight), index=movies)
        result.sort_values(inplace=True, ascending=False)
        return result

result = get_recommendation("Free State of Jones")
result2 = get_recommendation("Dark Skies")

print("*"*40+"\n Recommendation for 'Free State of Jones'\n"+"*"*40)
print(result.head())
print("*"*40+"\n Recommendation for 'Dark Skies'\n"+"*"*40)
print(result2.head())

```

```

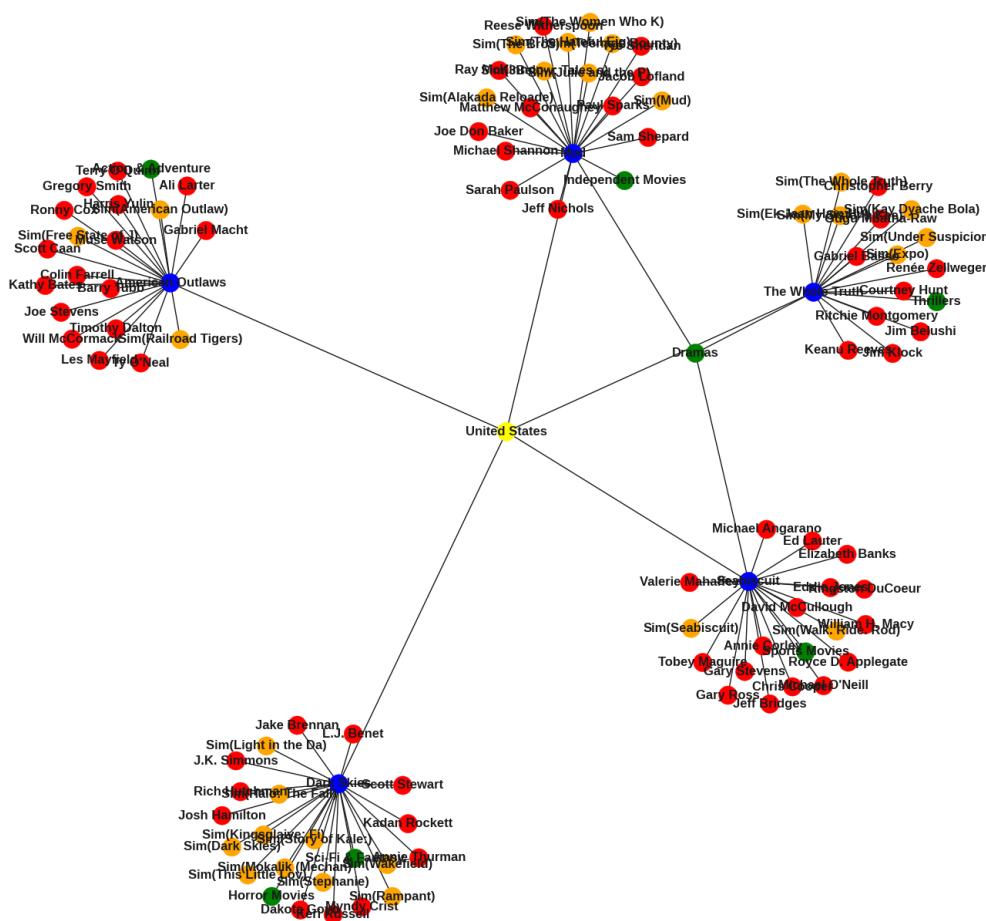
*****
Recommendation for 'Free State of Jones'
*****
Mud           2.314080
The Whole Truth 2.147864
Seabiscuit     1.692745
American Outlaws 1.385995
D.P.          1.116221
dtype: float64
*****
Recommendation for 'Dark Skies'
*****
Real Steel      1.746495
Light in the Dark 1.674332
Richie Rich     1.564448

```

```
Stephanie           1.408107
Legion             1.384173
dtype: float64
```

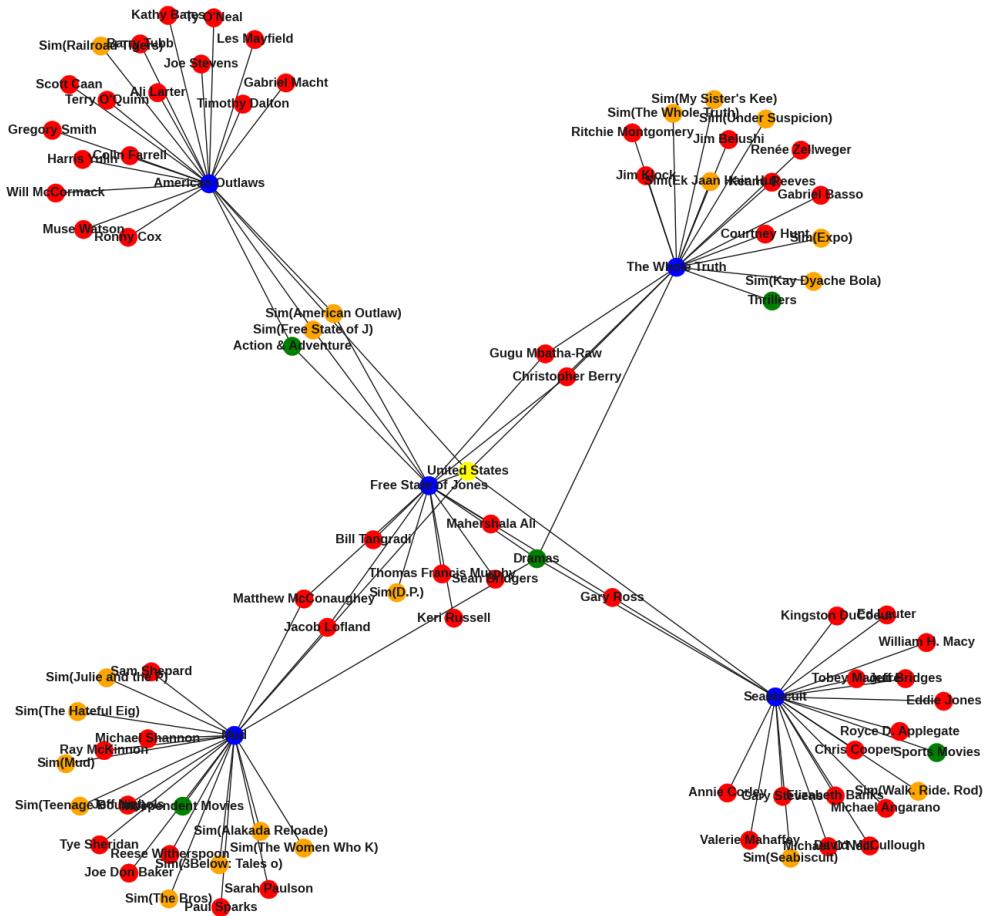
Plot Reccomendations to see the common nodes

```
[100]: reco=list(result.index[:4].values)
reco.extend(["Dark Skies"])
sub_graph = get_all_adj_nodes(reco)
draw_sub_graph(sub_graph)
```



```
[101]: reco=list(result.index[:4].values)
reco.extend(["Free State of Jones"])
sub_graph = get_all_adj_nodes(reco)
```

```
draw_sub_graph(sub_graph)
```



[]: