

Identifying Science Fiction Sub-Genres with NLP

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Introduction - How to Get Published

As a writer who has always dreamed of being published, one of the greatest challenges I have faced is coming to terms with the professional world of being an author. People don't get published simply because their work is 'good'. Harry Potter famously had trouble finding a publisher back in the day. To become a professional writer, one must not only write something good, but you must also navigate the tumultuous world of literary agents and publishers with budgets and deadlines.

This can all seem intimidating, and, quite frankly, that's because it is. It is also a massive hinderance to the next generation of writers who might not have masters degrees from Iowa State. We are also at a tipping point in the writing industry with the advent of publishers like Amazon who seek to change the publishing landscape. There are so many routes to take and none of them are 'correct', but some are better traversed than others and provide a little more guidance.

In science fiction, there are niche markets and mass markets, schlock and award winners. There are the books that get developed into HBO shows and long-running series that create more pulp than the entire legal industry combined. The one thing that is true for MOST books is that they have a literary agent. There are many, many resources explaining why literary agents are useful, not the least of which it's their entire job to get you published and they work solely on commission. So, how do you get one of these magical agents? Here is a quick check list:

- Write a fantastic query letter with a compelling plot description
- Associate your book with other successful books in the industry
- Make sure your writing sample is rock solid

Oh yes, and one small thing:

- FIND THE RIGHT AGENTS

This last one is a real doozy. Do you know how many literary agents there are out there? Neither do I, but there are a lot. Some are experienced and conservative, some are fresh and bold, but all are worthy of your research. The first thing to do is identify what kind of book you have written. Yes, we all like to say our books are special and unique, and that is predominantly true, but where does it fit in the literary landscape? Identifying what books are similar helps complete two objectives: first, it helps guide you as to where your book fits in and what other authors similar to you and, second, if a book is fairly similar, perhaps you should send a query to that book's agent. It couldn't hurt!



Objective

The purpose of this project was to build a tool that helps new authors attempt to break into the publishing industry. Due to the narrow (but deep) nature of my dataset, I built the model solely on Science Fiction novels, but I hope to expand its scope in the future to encompass Romance, Thrillers, Fantasy and, (gulp) maybe even general Fiction. Using Natural Language Processing, this tool will take in a book description (similar to a blurb on a book jacket) and tell you three key things:

- What subgenres does your story fall under?
- What age group does it seem appropriate for?
- What are the 10 most similar books currently on the market?

This Jupyter Notebook will take you through how I built and tuned my model as well as some examples on three book descriptions of novels I have written and (unsuccessfully) attempted to publish via the agent search.

Use Cases

Who is this for? Well, if you're interested in Natural Language Processing, I have built two classes housed in my utils file that I use for processing and testing models in only a couple of lines of code. Feel free to use and improve on them because they made this project shockingly swift (even if the processing time leaves a little to be desired). Secondly, if you are an author who has written at least a good chunk of a novel and you're hoping to start the publishing journey, here is the process I recommend:

- Write a plot summary in the same style as a book jacket blurb - follow examples of books you love
- Feed the summary into the processing tool

- Make sure that the appropriate genres and age groups show up - if they don't, use the most important words list to identify which words contributed to your scores
- Find the ten most similar novels to yours that were released in the last 10 years. Use those books in both your query letter (if they were moderately successful releases) and also use them to identify possible literary agents to submit your work to.

Okay, let's talk about how it all works.

The Data

I used the [Science Fiction Books Kaggle dataset \(<https://www.kaggle.com/tanguypledel/science-fiction-books-subgenres>\)](https://www.kaggle.com/tanguypledel/science-fiction-books-subgenres) of 11000 science fiction novels pulled from the Goodreads API. All of which came with several key data points: novel description, year published, Goodreads review/score numbers, and genre tags. The creator of the dataset originally pulled the top 1250 books in each of 12 major subgenres...however, that organization into genres was not necessarily useful. For example, a book that might be a popular cyberpunk book could also be a military story, but it is much better known for being cyberpunk. Therefore, it might show up on the cyberpunk list and not at all on the military one.

Instead, I used the user-generated genre tags pulled from Goodreads to get a stronger understanding of what genre each novel fits into. This creates a Multi-Label Classification problem. Any novel can be in multiple subgenres (just look at *Hitchhiker's Guide to the Galaxy!*) so the model needed to be able to assign multiple labels to each description. As for sorting into age groups, that is a Multi-Class Classification, much simpler and clearer-cut.

My original plan was to enrich this dataset with other novels from Goodreads...however the Goodreads API is no longer available to new users, so any future expansion of this project will require other avenues.

Data Loading and Cleaning

Let's import and start playing with book descriptions!

```
In [1]: import pandas as pd
import numpy as np
import nltk
import string
import re
from nltk.corpus import stopwords
from nltk import FreqDist
from wordcloud import WordCloud
from sklearn.feature_extraction.text import TfidfVectorizer, CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_score
from sklearn.preprocessing import LabelEncoder, OneHotEncoder, StandardScaler
from sklearn.pipeline import Pipeline
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics.pairwise import cosine_similarity
from sklearn import svm
from utils import process_text, TextSet, ModelComparison, age_group, find_genre
import matplotlib.pyplot as plt
import spacy
import time
import warnings
warnings.filterwarnings('ignore')
```

Below you can see each dataset of books loaded in and then combined into one large dataset with duplicate novels removed

```
In [2]: df_aliens = pd.read_csv('data/sf_aliens.csv')
df_aliens.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1250 entries, 0 to 1249
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1250 non-null    object  
 1   Original_Book_Title  1250 non-null    object  
 2   Author_Name      1250 non-null    object  
 3   Edition_Language 1250 non-null    object  
 4   Rating_score     1250 non-null    float64 
 5   Rating_votes     1250 non-null    int64   
 6   Review_number     1250 non-null    int64   
 7   Book_Description  1249 non-null    object  
 8   Year_published   1250 non-null    int64   
 9   Genres           1250 non-null    object  
 10  url              1250 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.5+ KB
```

```
In [3]: df_alt = pd.read_csv('data/sf_alternate_history.csv')
df_alt.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1249 entries, 0 to 1248
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title        1249 non-null    object  
 1   Original_Book_Title 1249 non-null    object  
 2   Author_Name       1249 non-null    object  
 3   Edition_Language  1248 non-null    object  
 4   Rating_score      1249 non-null    float64 
 5   Rating_votes      1249 non-null    int64   
 6   Review_number     1249 non-null    int64   
 7   Book_Description  1248 non-null    object  
 8   Year_published    1249 non-null    int64   
 9   Genres            1249 non-null    object  
 10  url               1249 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.5+ KB
```

```
In [4]: df_alt_u = pd.read_csv('data/sf_alternate_universe.csv')
df_alt_u.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1247 entries, 0 to 1246
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title        1247 non-null    object  
 1   Original_Book_Title 1247 non-null    object  
 2   Author_Name       1247 non-null    object  
 3   Edition_Language  1246 non-null    object  
 4   Rating_score      1247 non-null    float64 
 5   Rating_votes      1247 non-null    int64   
 6   Review_number     1247 non-null    int64   
 7   Book_Description  1247 non-null    object  
 8   Year_published    1247 non-null    int64   
 9   Genres            1247 non-null    object  
 10  url               1247 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.3+ KB
```

```
In [5]: df_app = pd.read_csv('data/sf_apocalyptic.csv')
df_app.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1248 entries, 0 to 1247
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1248 non-null    object  
 1   Original_Book_Title 1248 non-null    object  
 2   Author_Name      1248 non-null    object  
 3   Edition_Language 1243 non-null    object  
 4   Rating_score     1248 non-null    float64 
 5   Rating_votes     1248 non-null    int64   
 6   Review_number     1248 non-null    int64   
 7   Book_Description  1244 non-null    object  
 8   Year_published   1248 non-null    int64   
 9   Genres            1248 non-null    object  
 10  url               1248 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.4+ KB
```

```
In [6]: df_cyber = pd.read_csv('data/sf_cyberpunk.csv')
df_cyber.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1244 entries, 0 to 1243
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1244 non-null    object  
 1   Original_Book_Title 1244 non-null    object  
 2   Author_Name      1244 non-null    object  
 3   Edition_Language 1243 non-null    object  
 4   Rating_score     1244 non-null    float64 
 5   Rating_votes     1244 non-null    int64   
 6   Review_number     1244 non-null    int64   
 7   Book_Description  1226 non-null    object  
 8   Year_published   1244 non-null    int64   
 9   Genres            1244 non-null    object  
 10  url               1244 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.0+ KB
```

```
In [7]: df_dys = pd.read_csv('data/sf_dystopia.csv')
df_dys.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1242 entries, 0 to 1241
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1242 non-null    object  
 1   Original_Book_Title 1242 non-null    object  
 2   Author_Name      1242 non-null    object  
 3   Edition_Language 1241 non-null    object  
 4   Rating_score     1242 non-null    float64 
 5   Rating_votes     1242 non-null    int64   
 6   Review_number    1242 non-null    int64   
 7   Book_Description 1241 non-null    object  
 8   Year_published   1242 non-null    int64   
 9   Genres           1242 non-null    object  
 10  url              1242 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 106.9+ KB
```

```
In [8]: df_hard = pd.read_csv('data/sf_hard.csv')
df_hard.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1246 entries, 0 to 1245
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1246 non-null    object  
 1   Original_Book_Title 1246 non-null    object  
 2   Author_Name      1246 non-null    object  
 3   Edition_Language 1243 non-null    object  
 4   Rating_score     1246 non-null    float64 
 5   Rating_votes     1246 non-null    int64   
 6   Review_number    1246 non-null    int64   
 7   Book_Description 1219 non-null    object  
 8   Year_published   1246 non-null    int64   
 9   Genres           1246 non-null    object  
 10  url              1246 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.2+ KB
```

```
In [9]: df_mil = pd.read_csv('data/sf_military.csv')
df_mil.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1250 entries, 0 to 1249
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1250 non-null    object  
 1   Original_Book_Title 1250 non-null    object  
 2   Author_Name      1250 non-null    object  
 3   Edition_Language 1241 non-null    object  
 4   Rating_score     1250 non-null    float64 
 5   Rating_votes     1250 non-null    int64   
 6   Review_number    1250 non-null    int64   
 7   Book_Description 1249 non-null    object  
 8   Year_published   1250 non-null    int64   
 9   Genres           1250 non-null    object  
 10  url              1250 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.5+ KB
```

```
In [10]: df_rob = pd.read_csv('data/sf_robots.csv')
df_rob.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1250 entries, 0 to 1249
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1250 non-null    object  
 1   Original_Book_Title 1250 non-null    object  
 2   Author_Name      1250 non-null    object  
 3   Edition_Language 1247 non-null    object  
 4   Rating_score     1250 non-null    float64 
 5   Rating_votes     1250 non-null    int64   
 6   Review_number    1250 non-null    int64   
 7   Book_Description 1239 non-null    object  
 8   Year_published   1250 non-null    int64   
 9   Genres           1250 non-null    object  
 10  url              1250 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.5+ KB
```

```
In [11]: df_space = pd.read_csv('data/sf_space_opera.csv')
df_space.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1250 entries, 0 to 1249
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1250 non-null    object  
 1   Original_Book_Title 1250 non-null    object  
 2   Author_Name      1250 non-null    object  
 3   Edition_Language 1247 non-null    object  
 4   Rating_score     1250 non-null    float64 
 5   Rating_votes     1250 non-null    int64   
 6   Review_number     1250 non-null    int64   
 7   Book_Description  1248 non-null    object  
 8   Year_published   1250 non-null    int64   
 9   Genres            1250 non-null    object  
 10  url               1250 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.5+ KB
```

```
In [12]: df_steam = pd.read_csv('data/sf_steam_punk.csv')
df_steam.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1250 entries, 0 to 1249
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1250 non-null    object  
 1   Original_Book_Title 1250 non-null    object  
 2   Author_Name      1250 non-null    object  
 3   Edition_Language 1249 non-null    object  
 4   Rating_score     1250 non-null    float64 
 5   Rating_votes     1250 non-null    int64   
 6   Review_number     1250 non-null    int64   
 7   Book_Description  1246 non-null    object  
 8   Year_published   1250 non-null    int64   
 9   Genres            1250 non-null    object  
 10  url               1250 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.5+ KB
```

```
In [13]: df_time = pd.read_csv('data/sf_time_travel.csv')
df_time.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1248 entries, 0 to 1247
Data columns (total 11 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title       1248 non-null    object  
 1   Original_Book_Title 1248 non-null    object  
 2   Author_Name      1248 non-null    object  
 3   Edition_Language 1244 non-null    object  
 4   Rating_score     1248 non-null    float64 
 5   Rating_votes     1248 non-null    int64   
 6   Review_number     1248 non-null    int64   
 7   Book_Description  1247 non-null    object  
 8   Year_published   1248 non-null    int64   
 9   Genres           1248 non-null    object  
 10  url              1248 non-null    object  
dtypes: float64(1), int64(3), object(7)
memory usage: 107.4+ KB
```

Here is a quick view of one of the datasets. Notice that the Book Title would be considered the common title of the book while the 'Original_Book_Title' is sometimes a title used on the professional/publisher side.

```
In [14]: df.aliens.head()
```

Out[14]:

| | Book_Title | Original_Book_Title | Author_Name | Edition_Language | Rating_score | Rating_votes | Rev |
|---|--------------|---------------------|------------------------|------------------|--------------|--------------|-----|
| 0 | Obsidian | Obsidian | Jennifer L. Armentrout | English | 4.17 | 236780 | |
| 1 | Onyx | Onyx | Jennifer L. Armentrout | English | 4.27 | 153429 | |
| 2 | The 5th Wave | The 5th Wave | Rick Yancey | English | 4.03 | 400600 | |
| 3 | The Host | The Host | Stephenie Meyer | English | 3.84 | 915026 | |
| 4 | Opal | Opal | Jennifer L. Armentrout | None | 4.27 | 129006 | |

Data Exploration

Below you will see my first attempt to label each of the books. As I noted above, this was not the final approach that I took, but it's helpful to see the 12 categories that were original sourced from Goodreads.

```
In [15]: # Creates a combined dataset of all books, with any entry that has a duplicate
# name getting dropped

genre_list = [
    'aliens',
    'alternate_history',
    'alternate_universe',
    'apocalyptic',
    'cyberpunk',
    'dystopia',
    'hard',
    'military',
    'robots',
    'space_opera',
    'steampunk',
    'time_travel'
]

df_list = []

for genre in genre_list:
    df = pd.read_csv(f'data/sf_{genre}.csv')
    df.drop_duplicates(subset=['Book_Title', 'Author_Name'], inplace=True)
    df[f'{genre}'] = 1
    df_list.append(df)

df_books = pd.concat(df_list)
```

```
In [16]: # Creates the original multi-label table based on the 12 genres listed above
# Again, this was not used in the final model
genre_score = df_books[['Book_Title', 'Author_Name']] + [genre for genre in g
df_books = df_books.drop(columns=[genre for genre in genre_list]).drop_dupe
```

This dataframe below will be the core dataframe for the project. As I mentioned, it only has books that Goodreads considers Science Fiction, some of which are dubious choices. There are also a number of short story collections and self-published books that we will filter out when we consider both how recent the texts should be and how popular they should be. Nobody wants to say their novel is similar to a flop.

```
In [17]: df_desc = df_books.merge(genre_score, how='inner', on=['Book_Title', 'Author']
df_desc = df_desc.dropna(subset=['Book_Description']) # I dropped all rows
```

Ultimately, we have 11025 distinct books with a WIDE variety of scores, reviews and years published. As we'll see in a moment, the books skew modern, while a mean of 2001 but a median of 2012. This is a positive thing because we want as much of our sample to be relevant to contemporary publishing trends.

In [18]: df_desc.describe()

Out[18]:

| | Rating_score | Rating_votes | Review_number | Year_published | aliens | alternate_history |
|--------------|--------------|--------------|---------------|----------------|--------------|-------------------|
| count | 11025.000000 | 1.102500e+04 | 11025.000000 | 11025.000000 | 11025.000000 | 11025.000000 |
| mean | 3.923708 | 2.529002e+04 | 1355.155193 | 2001.996825 | 0.113197 | 0.113107 |
| std | 0.296662 | 1.684630e+05 | 5403.296914 | 100.414819 | 0.316848 | 0.316737 |
| min | 0.000000 | 0.000000e+00 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 25% | 3.730000 | 6.620000e+02 | 55.000000 | 2004.000000 | 0.000000 | 0.000000 |
| 50% | 3.930000 | 2.037000e+03 | 163.000000 | 2012.000000 | 0.000000 | 0.000000 |
| 75% | 4.130000 | 7.387000e+03 | 597.000000 | 2015.000000 | 0.000000 | 0.000000 |
| max | 5.000000 | 7.336299e+06 | 174079.000000 | 2021.000000 | 1.000000 | 1.000000 |

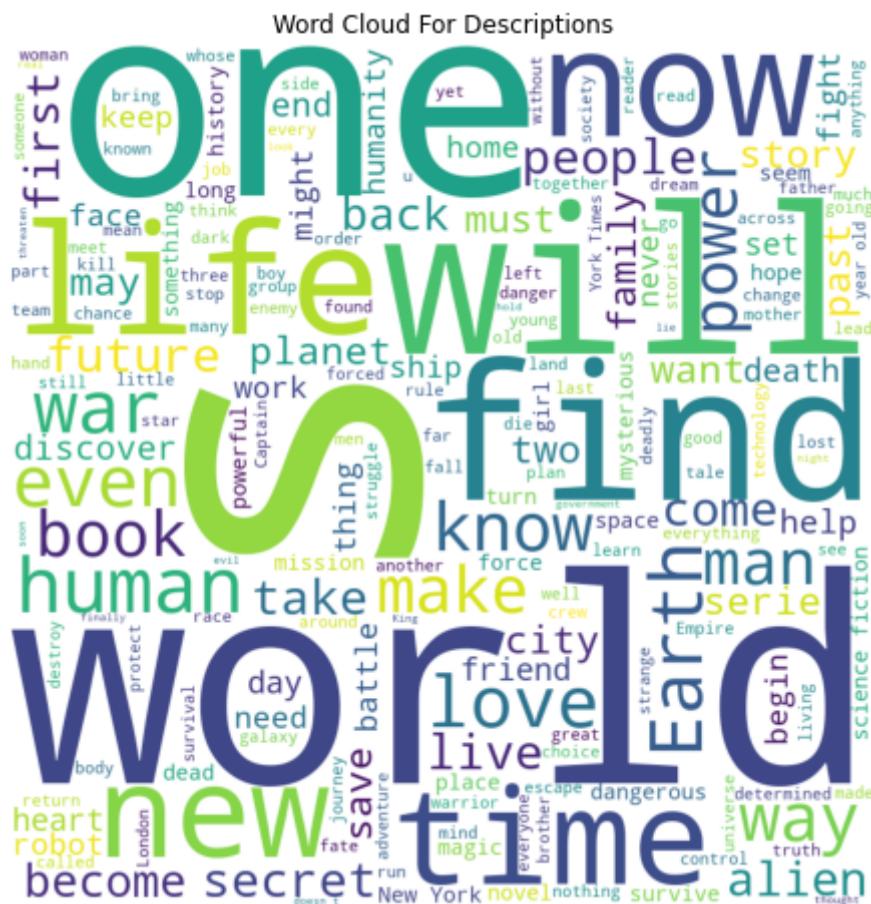
In [19]: df_desc.info()

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 11025 entries, 0 to 11094
Data columns (total 23 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Book_Title        11025 non-null   object 
 1   Original_Book_Title 11025 non-null   object 
 2   Author_Name       11025 non-null   object 
 3   Edition_Language  11000 non-null   object 
 4   Rating_score      11025 non-null   float64
 5   Rating_votes      11025 non-null   int64  
 6   Review_number     11025 non-null   int64  
 7   Book_Description  11025 non-null   object 
 8   Year_published    11025 non-null   int64  
 9   Genres            11025 non-null   object 
 10  url               11025 non-null   object 
 11  aliens            11025 non-null   float64
 12  alternate_history 11025 non-null   float64
 13  alternate_universe 11025 non-null   float64
 14  apocalyptic       11025 non-null   float64
 15  cyberpunk          11025 non-null   float64
 16  dystopia           11025 non-null   float64
 17  hard               11025 non-null   float64
 18  military            11025 non-null   float64
 19  robots              11025 non-null   float64
 20  space_opera         11025 non-null   float64
 21  steampunk           11025 non-null   float64
 22  time_travel          11025 non-null   float64
dtypes: float64(13), int64(3), object(7)
memory usage: 2.0+ MB
```

Now that we have a basic idea of our meta-data, let's drill into the descriptions. The first visualizations I find helpful are wordclouds and frequency distributions. Below you will see both, the

first frequency distribution contains stop words and core words.

```
In [20]: words = ' '.join(list(df_desc['Book_Description']))  
  
wordcloud = WordCloud(width = 800, height = 800,  
                      background_color ='white',  
                      min_font_size = 10).generate(words)  
  
# plot the WordCloud image  
plt.figure(figsize = (6, 6), facecolor = None)  
plt.imshow(wordcloud)  
plt.axis("off")  
plt.tight_layout(pad = 0)  
plt.title(f'Word Cloud For Descriptions')  
plt.show()
```



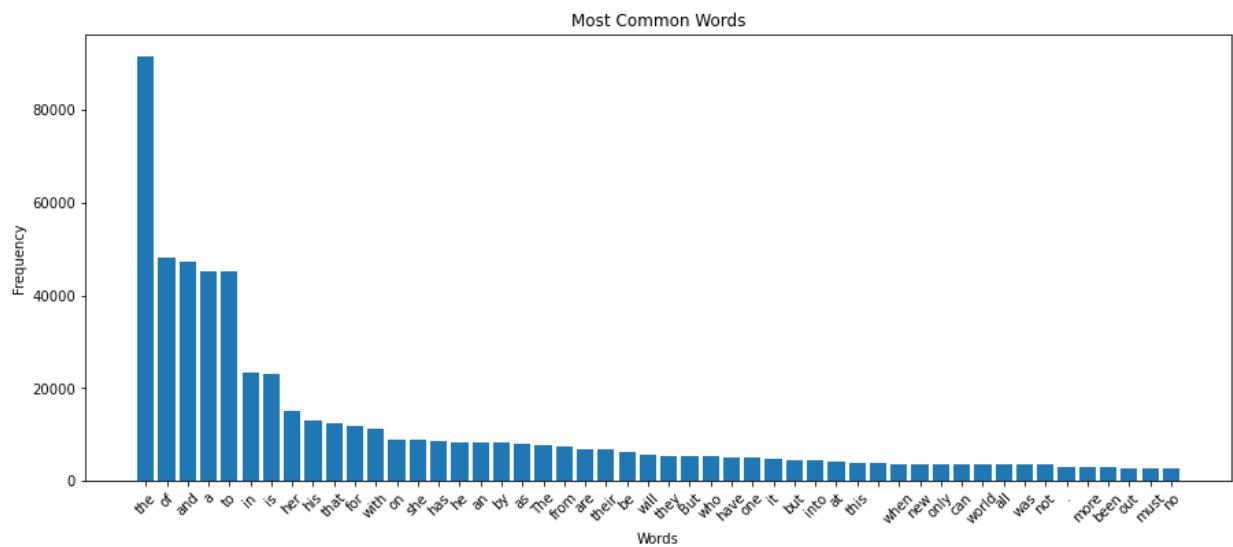
```
In [21]: words = ' '.join(list(df_desc['Book_Description']))
tokens = words.split(' ')

data_freqdist = FreqDist(tokens)

x = []
y = []

for token in data_freqdist.most_common(50):
    x.append(token[0])
    y.append(token[1])

plt.figure(figsize=(15, 6))
plt.bar(x=x, height=y)
plt.xticks(rotation=45)
plt.xlabel('Words')
plt.title(f'Most Common Words')
plt.ylabel('Frequency')
plt.show()
```



As with any NLP project, removing stop words is essential to analysis. I used the basic stop word dictionary from the Natural Language Tool Kit from Sklearn and added a few unique symbols that tended to muddy the data.

```
In [22]: stopwords_list = stopwords.words('english') + [ ' ', ' ', ' ', ' ', ' ', 'w/ ', 's ',
```

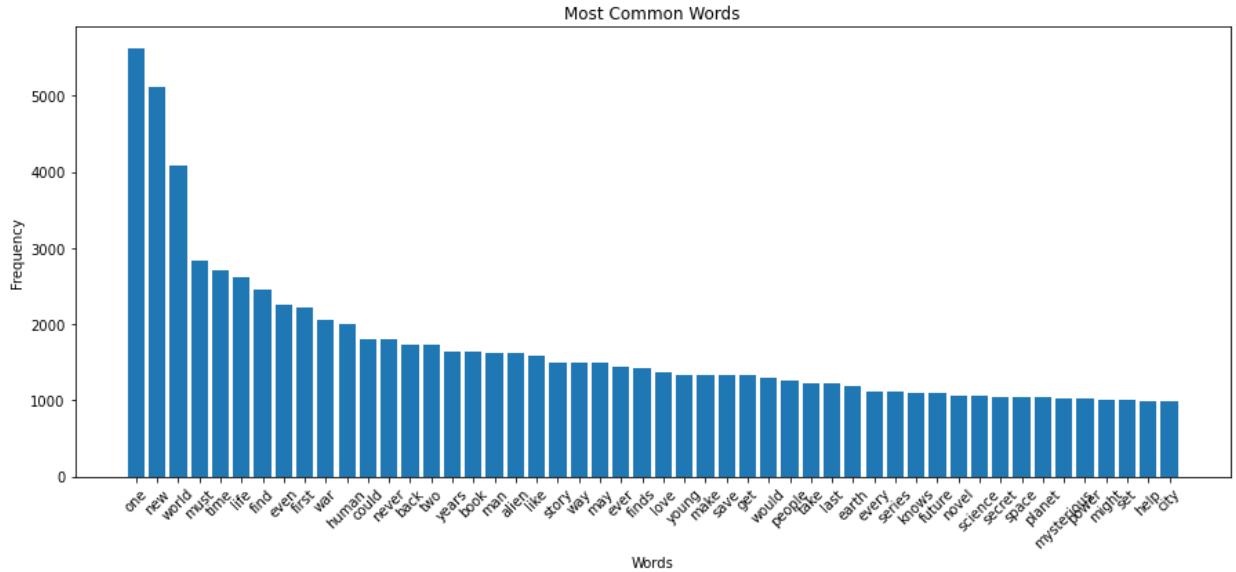
```
In [23]: # Second frequency distribution, but with no stop words.
clean_tokens = [word.lower() for word in tokens if word.lower() not in stop

data_freqdist = FreqDist(clean_tokens)

x = []
y = []

for token in data_freqdist.most_common(50):
    x.append(token[0])
    y.append(token[1])

plt.figure(figsize=(15, 6))
plt.bar(x=x, height=y)
plt.xticks(rotation=45)
plt.xlabel('Words')
plt.title(f'Most Common Words')
plt.ylabel('Frequency')
plt.show()
```



Already we can see that this is definitely a collection of science fiction stories. 'New', 'world', 'time', 'war', 'human', and 'alien' are key words in science fiction storytelling. Based on the first 50 words in the distribution, this feels like enough stopword preprocessing to start.

Let's have a look at the reviews, votes and years published to note any outliers.

```
In [24]: df_desc['Review_number'].describe()
```

```
Out[24]: count    11025.000000
mean     1355.155193
std      5403.296914
min      0.000000
25%     55.000000
50%    163.000000
75%    597.000000
max    174079.000000
Name: Review_number, dtype: float64
```

```
In [25]: df_desc['Rating_votes'].describe()
```

```
Out[25]: count    1.102500e+04
mean     2.529002e+04
std      1.684630e+05
min      0.000000e+00
25%     6.620000e+02
50%    2.037000e+03
75%    7.387000e+03
max    7.336299e+06
Name: Rating_votes, dtype: float64
```

```
In [27]: # Randomly selects a portion of the book descriptions
test_df = df_pop.sample(n=15, random_state=42)
str(test_df['Book_Description'])
```

```
Out[27]: '2486      Narnia... the land beyond the wardrobe door, a s...\\n2990      The
breakout hit of the biggest Spider-Event o...\\n3547      A penetrating, pa
ge-turning tour of a post-hum...\\n318      When a massive object crashes
into the ocean o...\\n1703      This is the world. It is not the one we wan
ted...\\n697      As far as job hazards go, Douglass Fraser didn...\\n7579
Far in the future, 60,000 light-years from Ear...\\n2730      A masterful t
ale of ambition, jealousy, desire...\\n2267      Presenting for the first t
ime the adventures o...\\n2953      Rebel by chance. Traitor by choice. Guns
linger ...\\n8361      Listening Length: 5 hours and 18 minutesA capt...\\n5
197      Iko – an audacious android and best friend to ...\\n3354      When
all else comes to naught, a steadfast hea...\\n10305      When Nigel Walden
is fourteen, the unhappening...\\n10576      In this stunning, imaginative n
ovel, Eve Marie...\\nName: Book_Description, dtype: object'
```



Descriptions - Pre-Processed Before NLP

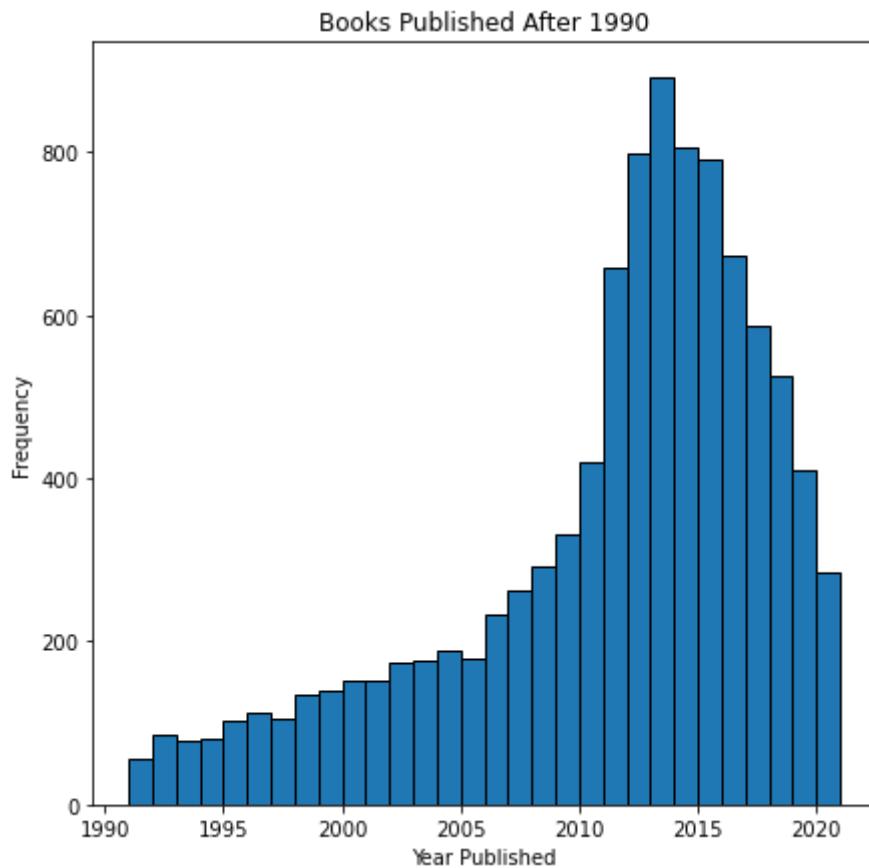
One of the strengths of this project is based on the similarity of the style of each book description. When analyzing comments on the internet or on twitter, there is little to no rhyme or reason to how people type. Some tweets can be riddled with urls or typos, increasing the sample noise. However, for this project, each book description is connected with a published book. That means this blurb has very likely passed through the hands of a marketing team who has a certain style and way of approaching the market. These descriptions were not written by amateur authors, but rather professionals and therefore they all have a similarity in style and a baseline of quality.

```
In [28]: test_df['Book_Description'].iloc[2]
```

Out[28]: "A penetrating, page-turning tour of a post-human EarthIn The World Without Us, Alan Weisman offers an utterly original approach to questions of humanity's impact on the planet: he asks us to envision our Earth, without us. In this far-reaching narrative, Weisman explains how our massive infrastructure would collapse and finally vanish without human presence; which everyday items may become immortalized as fossils; how copper pipes and wiring would be crushed into mere seams of reddish rock; why some of our earliest buildings might be the last architecture left; and how plastic, bronze sculpture, radio waves, and some man-made molecules may be our most lasting gifts to the universe.The World Without Us reveals how, just days after humans disappear, floods in New York's subways would start eroding the city's foundations, and how, as the world's cities crumble, asphalt jungles would give way to real ones. It describes the distinct ways that organic and chemically treated farms would revert to wild, how billions more birds would flourish, and how cockroaches in unheated cities would perish without us. Drawing on the expertise of engineers, atmospheric scientists, art conservators, zoologists, oil refiners, marine biologists, astrophysicists, religious leaders from rabbis to the Dalai Lama, and paleoanthropologists—who describe a prehuman world inhabited by megafauna like giant sloths that stood taller than mammoths—Weisman illustrates what the planet might be like today, if not for us.From places already devoid of humans (a last fragment of primeval European forest; the Korean DMZ; Chernobyl), Weisman reveals Earth's tremendous capacity for self-healing. As he shows which human devastations are indelible, and which examples of our highest art and culture would endure longest, Weisman's narrative ultimately drives toward a radical but persuasive solution that needn't depend on our demise. It is narrative nonfiction at its finest, and in posing an irresistible concept with both gravity and a highly readable touch, it looks deeply at our effects on the planet in a way that no other book has."

Now let's see how the year distribution breaks down.

```
In [29]: # Plots only the novels that were published after 1990
x = df_desc[df_desc['Year_published'] > 1990]['Year_published']
plt.figure(figsize=(7,7))
plt.hist(x=x, bins=30, edgecolor='black')
plt.title('Books Published After 1990')
plt.ylabel('Frequency')
plt.xlabel('Year Published')
plt.show()
```



As we can see, the novels skew modern, which is a good thing. Also, it's important to note that the books on Goodreads are frequently for editions currently on the market. The author doesn't write the book blurb, the current publisher's marketing team does. Therefore, while the subject matter of the older stories might skew into different themes, the blurb style is still similar and contemporary.

Let's continue processing the data to get it ready for modeling. First, we need to extract the genres provided by Goodreads to create our target columns. I created a simple function for the dataframe that can be found in the utils file.

```
In [30]: # Adds a 'genres' column which is a list of genres from Goodreads
df_desc['genres'] = df_desc['Genres'].map(lambda x: find_genre(x))
```

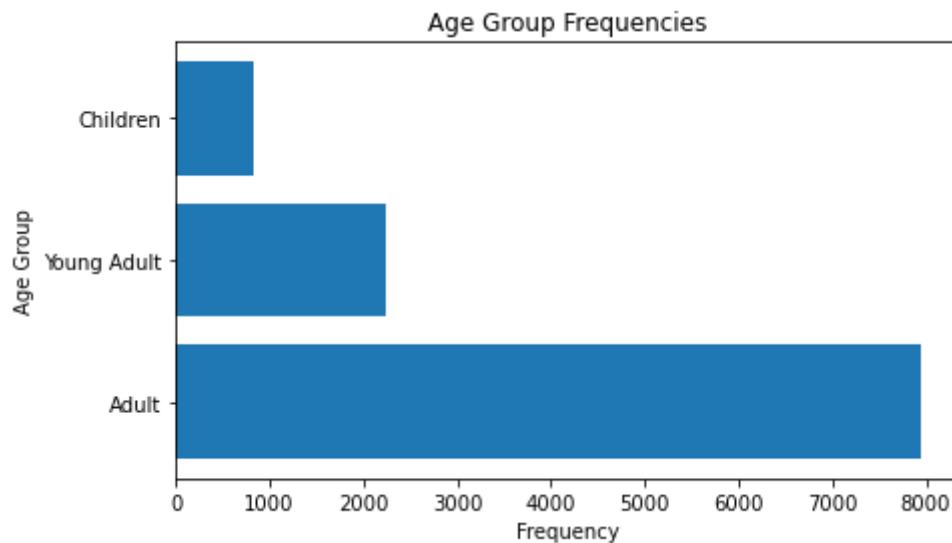
First we are going to assign the age group. To do this I created another quick function that's in the utils file. While some books could be classified in multiple ways, I rounded down. If a book is child appropriate, then it's 'Children'. If it was labeled 'Young Adult' and wasn't labeled 'Children', it returns 'Young Adult'. 'Adult' is the default return.

This is how each category breaks down:

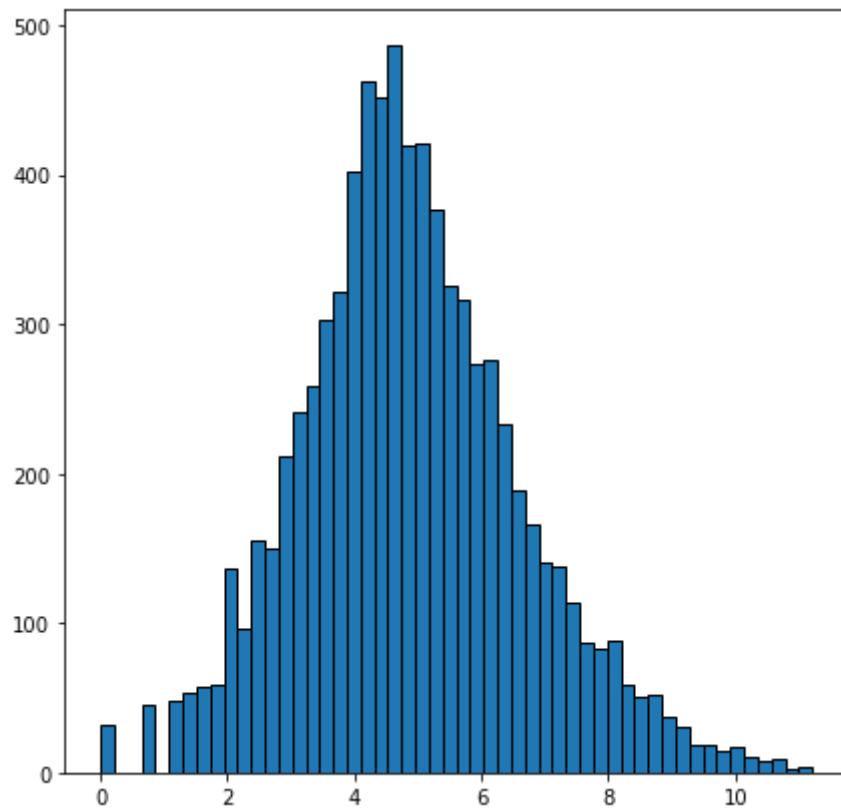
```
In [31]: # Creates the Age Group target column
df_desc['Age_Group'] = df_desc['Genres'].map(lambda x: age_group(x))
```

```
In [46]: # Plots the Age Groups for comparison
x = list(dict(df_desc['Age_Group'].value_counts()).keys())
y = list(dict(df_desc['Age_Group'].value_counts()).values())

plt.figure(figsize=(7,4))
plt.barh(y=x, width=y)
plt.title('Age Group Frequencies')
plt.ylabel('Age Group')
plt.xlabel('Frequency')
plt.show()
```

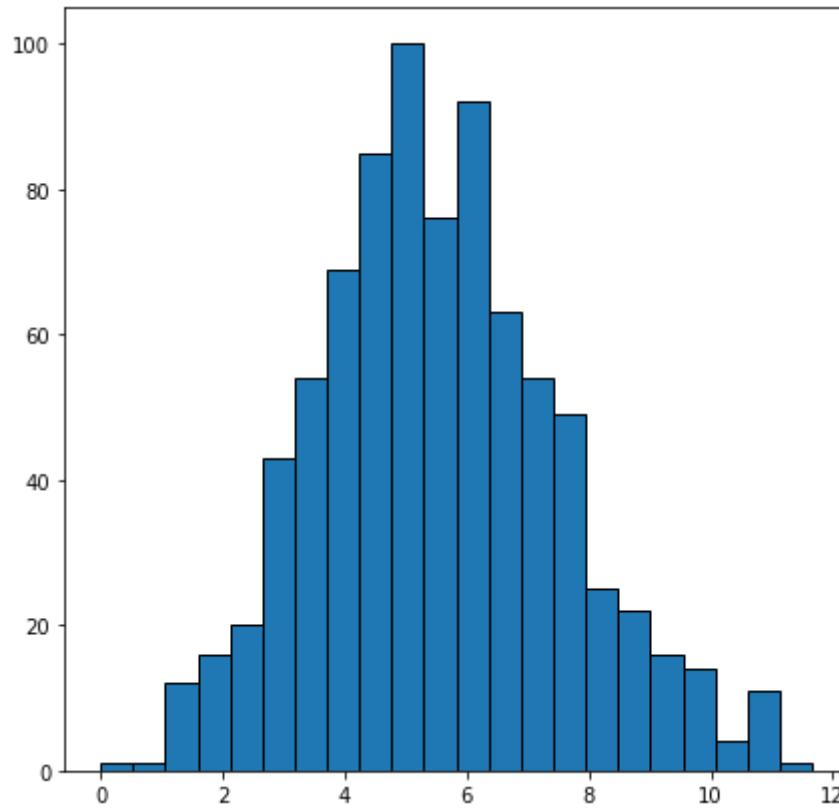


```
In [33]: # A log transformation of the review number of all adult novels. It follows
y = [np.log1p(x) for x in df_desc[df_desc['Age_Group'] == 'Adult']['Review_'
plt.figure(figsize=(7,7))
plt.hist(y, bins='auto', edgecolor='black')
plt.show()
```

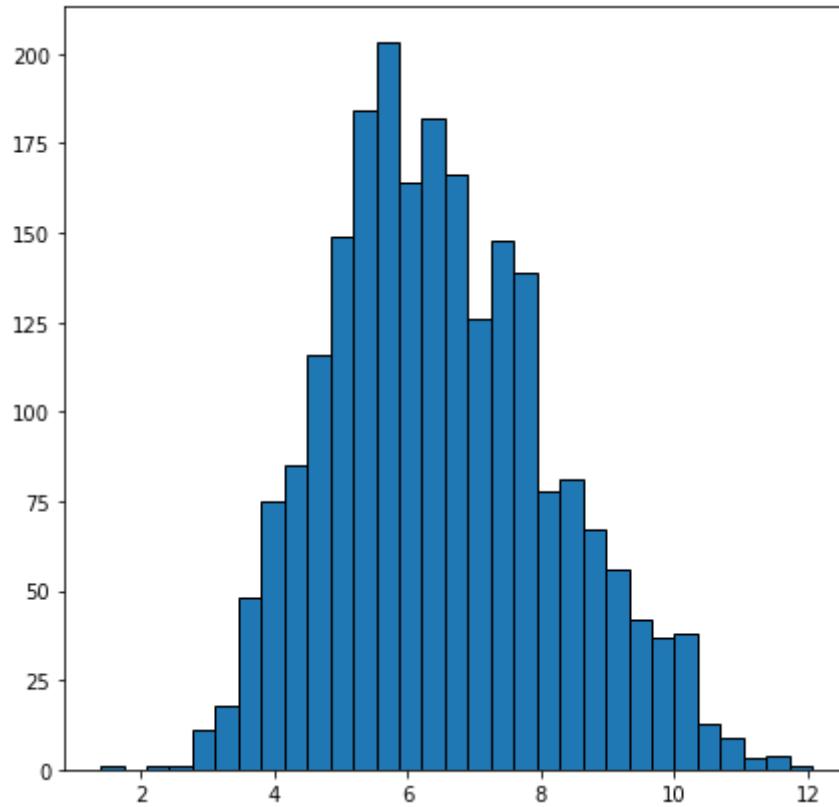


```
In [34]: # Same thing, but for Children's/Middle Grade books
```

```
y = [np.log1p(x) for x in df_desc[df_desc['Age_Group'] == 'Children']['Review']]  
plt.figure(figsize=(7,7))  
plt.hist(y, bins='auto', edgecolor='black')  
plt.show()
```



```
In [35]: # And finally for young adult. All of them looked fairly normal.
y = [np.log1p(x) for x in df_desc[df_desc['Age_Group'] == 'Young Adult'][['R
plt.figure(figsize=(7,7))
plt.hist(y, bins='auto', edgecolor='black')
plt.show()
```



Text Processing

There are multiple ways to process text in Natural Language Processing. For each model, I decided to try multiple methods of vectorization. In my `TextSet` class we can set the processing parameters and then my `ModelComparison` class allows me to evaluate the performance of each processing method against one another. Here are the three methods that I will explore:

SpaCy

SpaCy is (as of this writing) a newer NLP toolset that has its own pretrained library based on 100 million Wikipedia articles. SpaCy has a number of impressive inherent features such as a pipeline that can identify Proper Nouns in sentences as well as attaching parts of speech to words. It is also a powerful tokenizer that will automatically lemmatize words. SpaCy also has a doc2vec vectorization method that I will be using. Without removing stopwords and punctuation, SpaCy can turn paragraphs into vectors fairly quickly.

In my experience, the doc2vec method has produced lackluster results, but I'm not 100% sure I'm using the vectorization method in the best way.

Count Vectorization/Bag of Words

The second method is simply count vectorization. This means we find the most common words in the entire corpus of the book descriptions, remove all stop words, and then vectorize based on the frequency of each of those common words in each description. We saw 'human' and 'war' are two of the most common words in the dataset. If description A has 2 'human' mentions and 0 'war' mentions, the vector would be:

```
[ 2 , 0 ]
```

And if description B had 1 'human' mention and 3 'war' mentions, its vector would look like:

```
[ 1 , 3 ]
```

Unfortunately, this method was also fairly inaccurate ultimately. I did, however, save the best 'til last:

TF-IDF Vectorization

This is, hands-down, my favorite vectorization method available. Similar to the count vectorization method, Term Frequency-Inverse Document Frequency (TF-IDF) vectorization wants to know two things: how many common words are in each document AND are there certain documents where those words DON'T show up. Think about a hard science description versus a romantic space opera. The space opera would have far more heroic, epic words while the hard science one might have words like 'science' and 'experiment' etc. Already you get a stronger picture of the genre or age group by knowing both dimensions. This method is far more effective in text classification in the two projects I've completed with NLP.

TF-IDF can also be tweaked with how many common words do we want to track as well as increasing the n-gram range. Sometimes words are more common in pairs than alone. For example, the word opera is probably not going to show up without 'space' in front of it. I will be exploring multiple vectorization methods using these parameters.

Let's start the vectorization process!

```
In [36]: nlp = spacy.load("en_core_web_sm") #Loads Spacy, an essential library for t
```

```
In [37]: # The Spacy dataset, includes stop words.
spacy_1 = TextSet(X=df_desc['Book_Description'], # The processing column is
                  y=df_desc['Age_Group'], # The Target column is the Age Gr
                  name = 'Spacy 1',
                  is_spacy=True,
                  keep_stopwords=True,
                  random_seed=42)
```

```
--- 632.5671212673187 seconds ---
```

```
In [38]: # The first of 3 TF-IDF processing methods. This one will have 400 features
tf_idf_400_2 = TextSet(X=df_desc['Book_Description'],
                      y=df_desc['Age_Group'],
                      name='tf-idf_400_2',
                      is_spacy=False, # Stop words are removed with TF-IDF
                      keep_stopwords=False)
```

--- 638.6462409496307 seconds ---

```
In [39]: Second TF-IDF - this one will only look at single words but will not be bounded by sentences
tf_idf_None = TextSet(X=df_desc['Book_Description'],
                      y=df_desc['Age_Group'],
                      name='tf-idf_None',
                      is_spacy=False,
                      keep_stopwords=False)
```

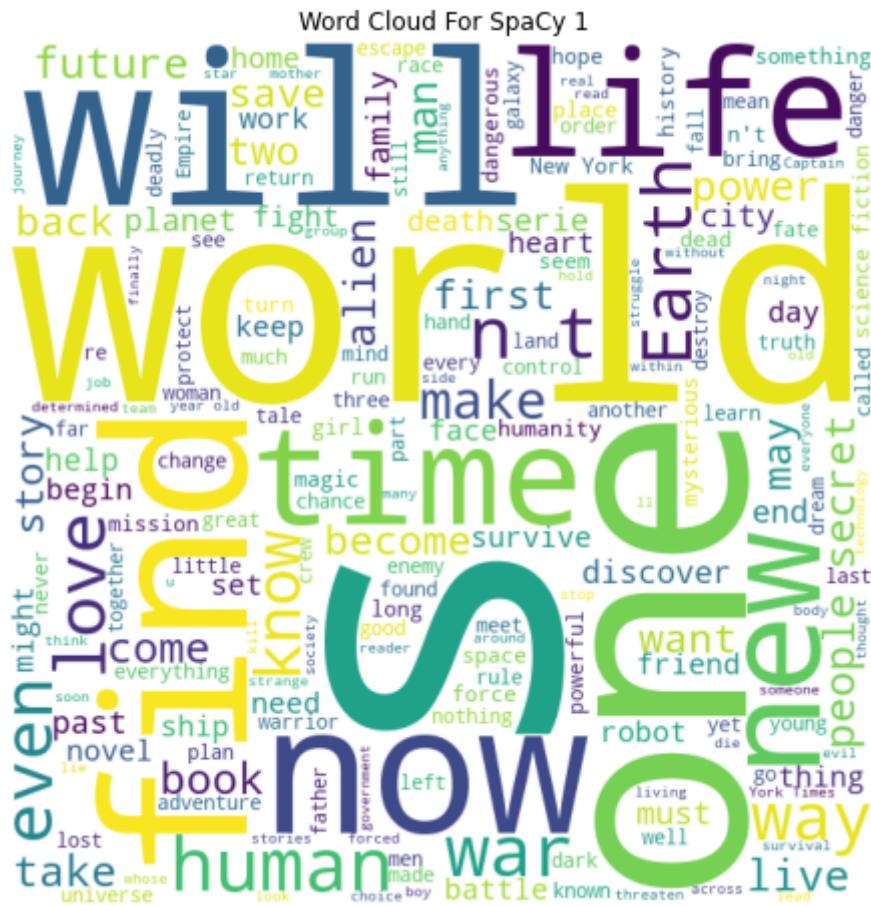
--- 641.4852359294891 seconds ---

```
In [40]: # The last TF-IDF method - 400 words will be measured, but only one word, not the whole sentence
tf_idf_400_1 = TextSet(X=df_desc['Book_Description'],
                      y=df_desc['Age_Group'],
                      name='tf-idf_400_1',
                      is_spacy=False,
                      keep_stopwords=False)
```

--- 643.9909110069275 seconds ---

As you can see, the word clouds for each dataset is similar, but slightly different.

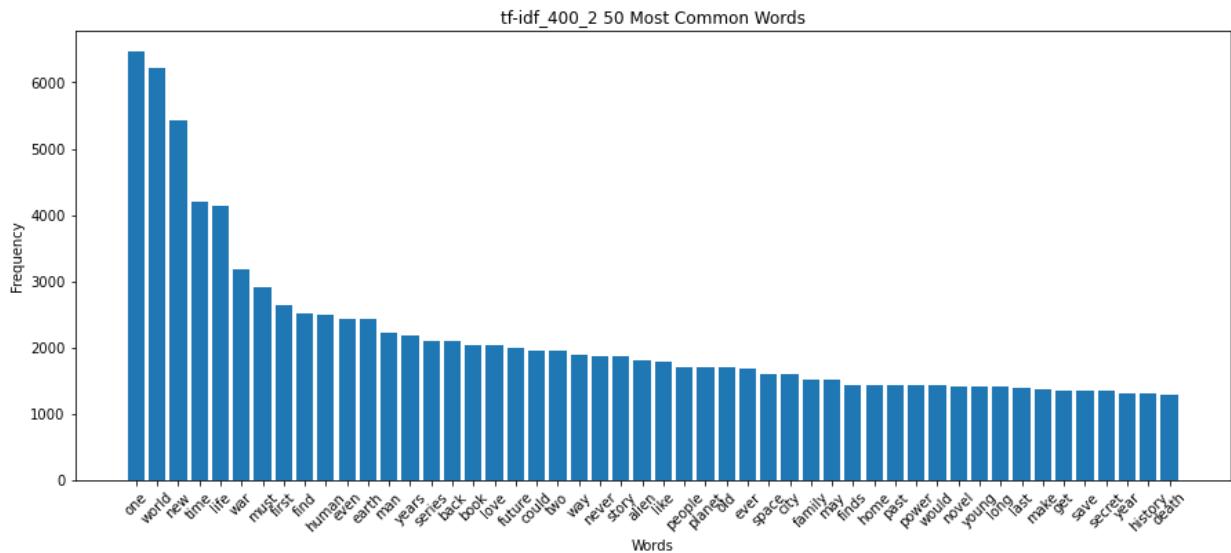
```
In [41]: spacy_1.word_cloud()
```



```
In [42]: tf_idf_400_2.word_cloud()
```



```
In [43]: tf_idf_400_2.plot_frequency()
```



```
In [44]: # Vectorizes each dataset based on the parameters required to test the diff
spacy_1.vectorize()
tf_idf_400_2.vectorize(max_features=400, ngram_range=(1,2))
tf_idf_None.vectorize(max_features=None)
tf_idf_400_1.vectorize(max_features=400)
```

```
In [45]: # Creates the data list for processing
data = [spacy_1, tf_idf_400_2, tf_idf_None, tf_idf_400_1]
```

Model 1 - Age Group

The first model that I built predicts the age group that would be the novel's target audience. As I mentioned above, this is a multi-class classification, not a multi-label one. As you can see, the majority class (adult) of the dataset is 72% of the values, meaning that our model has to have an accuracy of higher than 72% to be considered effective.

```
In [46]: df_desc['Age_Group'].value_counts(normalize=True)
```

```
Out[46]: Adult      0.721179
Young Adult  0.203719
Children     0.075102
Name: Age_Group, dtype: float64
```

```
In [ ]: df_desc['Age_Group']
```

While I did try a few modeling methods, I have found that the Support Vector Machine classifier has the best results on text classification. Below, you can see commented-out code for a GridSearch, which I used to find out the ideal parameters for the model. However, running it sometimes crashed my laptop. To avoid this, I have filled in the final parameters of the best model already and I ran those without the gridsearch included.

The ModelComparison class object takes in the datasets that we have already vectorized and trains the model on each of the datasets in turn (returning the length of time it took to process each one as well). It produces results for each dataset in turn and can also show confusion squares on multi-class and binary classification problems.

```
In [47]: The Support Vector Machine model for Age Group classification.
n_pipe = Pipeline([('scaler', StandardScaler()), ('rbf', svm.SVC(kernel='rbf'))]

grid= {
    'rbf_kernel': ['rbf', 'sigmoid'],
    'rbf_gamma' : ['scale', 'auto'],
    'rbf_C': [1, 100, 1e12],
    'rbf_decision_function_shape': ['ovo', 'ovr']
}

svm_grid = GridSearchCV(svm_pipe, param_grid=grid, scoring='accuracy', cv=5)
n_compare = ModelComparison(pipeline=svm_pipe, data_list=data, y_format='lab')
```

```
In [48]: svm_compare.fit_models()
svm_compare.score_comparison
```

```
SpaCy 1 finished in 10.01484990119934 seconds
tf-idf_400_2 finished in 30.09706687927246 seconds
tf-idf_None finished in 4734.208377122879 seconds
tf-idf_400_1 finished in 32.30858397483826 seconds
--- 4807.374222278595 seconds to process ---
```

Out[48]:

| | SpaCy 1 Test | tf-idf_400_2 Test | tf-idf_None Test | tf-idf_400_1 Test |
|--------------------------|--------------|-------------------|------------------|-------------------|
| Accuracy | 0.704064 | 0.773933 | 0.765536 | 0.769903 |
| Precision (Macro) | 0.493747 | 0.697084 | 0.857003 | 0.676301 |
| Recall (Macro) | 0.439075 | 0.520615 | 0.447846 | 0.510562 |
| F1 (Macro) | 0.451899 | 0.560019 | 0.479466 | 0.547340 |

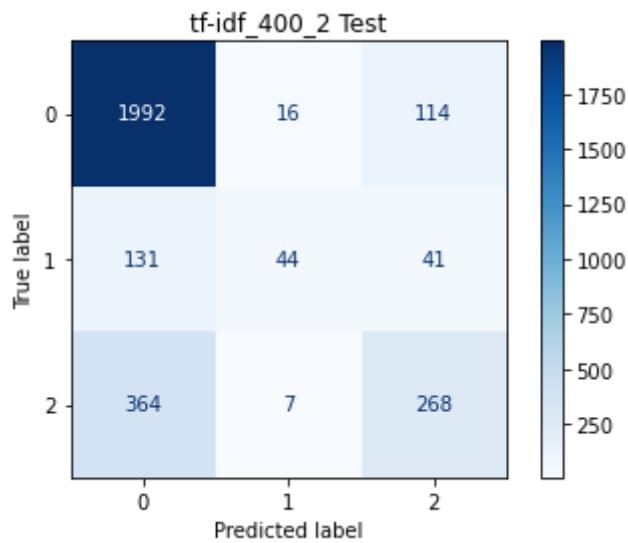
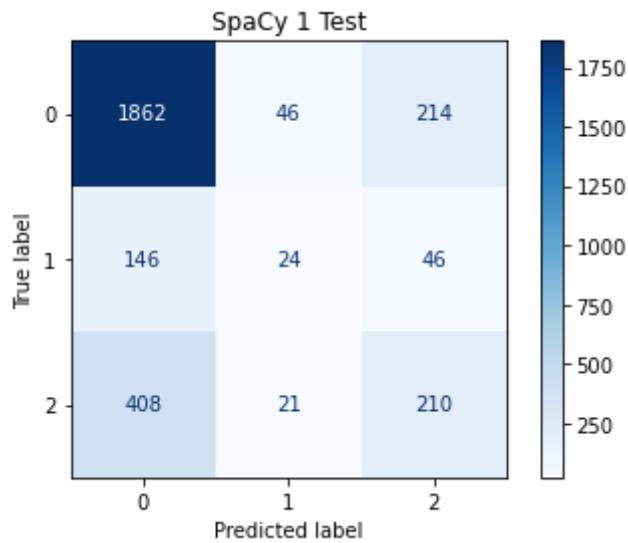
Observations

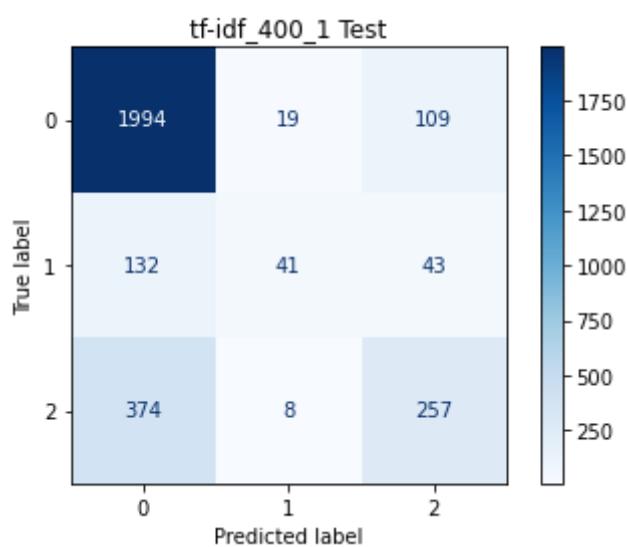
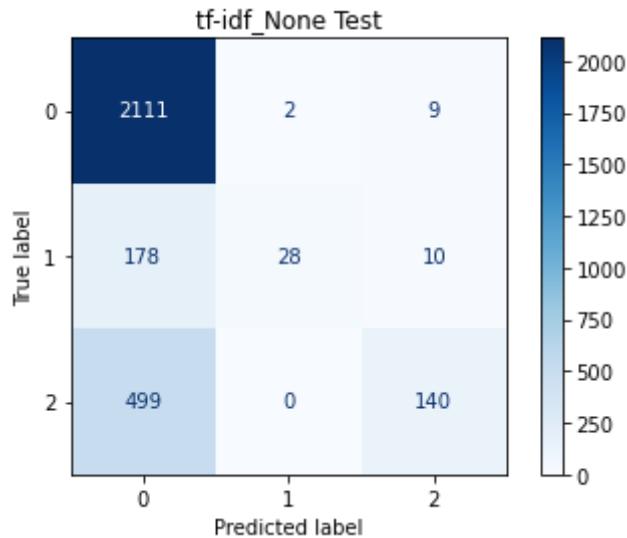
As we can see, the TF-IDF Vectorization dataset with 400 words considered and a word length of 1 or 2 words long was the most accurate model with an accuracy of 77.4%, precision of 69% and recall of 52%. When performing my gridsearches, I optimized my accuracy, which counts how often the model guessed correctly. Interestingly, the dataset with the most columns (TF-IDF None) had poorer accuracy but much higher precision than the other models. It also took 142 times longer to finish fitting the data.

Precision measures the chance that if you guess something is a class, how often you are correct, while **Recall** measures how often you say it ISN'T a class and how often your guess is correct. **F1 Scores** are a balance between precision and recall. We would like to see a balance in all four scores which is why they are included. The TF-IDF_400_2 dataset has the best scores in everything other than Precision.

If we want to see these scores visualized, here's the Confusion Matrix of each dataset. For Confusion Matrices, we always want the top left to bottom right diagonal to have the highest values because that is where the model predicted the correct labels. As you can see, the model really tries to guess the majority class more often than not, which is absolutely sensible. That said, the TF-IDF_400_2 has a decent balance between false positives and false negatives.

```
In [49]: svm_compare.compare_confusion()
```





What does 'good' look like?

Remember, this isn't supposed to be a black box algorithm, meaning that, in the end, I want the user to be able to see *why* their description returned certain scores. This means that we might not care as much about correctly predicting the age group, but rather ranking the probabilities of each genre. That way, when you tweak your description, you can see those probabilities increase or decrease.

Also, those scores are the *test* results. Let's see how we did on the *holdout* dataset.

```
In [50]: svm_compare.calc_scores(data_type='holdout') # Recalculates the scoring with
svm_compare.score_comparison
```

Out[50]:

| | SpaCy 1 Holdout | tf-idf_400_2 Holdout | tf-idf_None Holdout | tf-idf_400_1 Holdout |
|--------------------------|-----------------|----------------------|---------------------|----------------------|
| Accuracy | 0.699909 | 0.783318 | 0.763373 | 0.778785 |
| Precision (Macro) | 0.506496 | 0.734752 | 0.834976 | 0.740954 |
| Recall (Macro) | 0.434593 | 0.535429 | 0.445494 | 0.535530 |
| F1 (Macro) | 0.449797 | 0.583244 | 0.476560 | 0.585351 |

Once again TF-IDF_400_2 did better than the other datasets. This time, interesting, the holdout dataset has better scores than the testing dataset, which leads me to believe that the model is underfit or there is too much noise in the main testing data. In any case, TF-IDF_400_2 is the way to go.

Now, we need to isolate a few things. First we need to train the model on the best dataset (the ModelComparison object trains the models on sequential datasets, so it's always left trained on the final dataset), then we need to save the **trained model** and, crucially, the **text vectorizer**

```
In [51]: # This is the same model, simply run on the main dataset
svm_pipe = Pipeline([('scaler', StandardScaler(with_mean=False)), ('rbf', sv
svm_compare = ModelComparison(pipeline=svm_pipe, data_list=[tf_idf_400_2],
svm_compare.fit_models()
svm_compare.score_comparison
```

tf-idf_400_2 finished in 85.00200486183167 seconds
--- 85.01161694526672 seconds to process ---

Out[51]:

tf-idf_400_2 Test

| | |
|--------------------------|----------|
| Accuracy | 0.774269 |
| Precision (Macro) | 0.697872 |
| Recall (Macro) | 0.521137 |
| F1 (Macro) | 0.560647 |

In [52]: svm_compare.all_scores

Out[52]:

tf-idf_400_2 Train tf-idf_400_2 Test

| | tf-idf_400_2 Train | tf-idf_400_2 Test |
|--------------------------|--------------------|-------------------|
| Accuracy | 0.998848 | 0.774269 |
| Precision (Macro) | 0.999472 | 0.697872 |
| Recall (Macro) | 0.998061 | 0.521137 |
| F1 (Macro) | 0.998763 | 0.560647 |

In [53]: # Saves the age model and the vectorizer for later.

```
age_model = svm_compare.pipeline
age_vectorizer = tf_idf_400_2.vectorizer
```

In [54]: age_model_2 = svm_compare.pipeline

And now we have our Age Model ready to go and our vectorizer to create a processing pipeline!



Model 2 - Genre Prediction

As I have stated, the genre prediction is a much more complicated challenge compared to the multi-class classification of age identification. For Genre we have to do some more preprocessing once more.

When we bypassed the genre groupings suggested by the dataset, we pulled in every tag assigned to each book. As far as I understand it, Goodreads allows users to tag a book with a genre, offering hundreds of sub and sub sub genres to pick from. This is both wonderful, because humans did a lot of our hard work for us, and annoying, because the data is *really* messy. To create an exhaustive list of the possible genre tags I used the following function:

```
In [55]: genre_dict = {}

def generate_genre_dict(x):

    for genre in x:
        if genre in genre_dict.keys():
            genre_dict[genre] += 1
        else:
            genre_dict[genre] = 0
```

When applied to the dataframe, it returns nothing but builds our genre dictionary for us:

```
In [56]: df_desc['genres'].map(lambda x: generate_genre_dict(x))
```

```
Out[56]: 0      None
1      None
2      None
3      None
4      None
...
11090   None
11091   None
11092   None
11093   None
11094   None
Name: genres, Length: 11025, dtype: object
```

Next, we need to sort through the genres to find the most commonly mentioned genres/tags.

```
In [57]: genre_dict = dict(sorted(genre_dict.items(), key=lambda item: item[1], rever
```

In the end, we get this messy thing:

In [58]: genre_dict

```
'Business (Amazon)': 351,
'Anthologies': 338,
'Comics (Comic Book)': 322,
'Romance (M M Romance)': 308,
'Adventure (Survival)': 303,
'Fantasy (High Fantasy)': 296,
'Science Fiction (Hard Science Fiction)': 278,
'Mystery (Crime)': 242,
'Sequential Art (Manga)': 232,
'Romance (Time Travel Romance)': 228,
'Paranormal (Shapeshifters)': 217,
'GLBT (Queer)': 209,
'Fantasy (Dragons)': 193,
'Suspense': 193,
'Adult Fiction': 187,
'Childrens (Juvenile)': 182,
'Literature': 177,
'Historical Fiction (Historical Fantasy)': 174,
'Childrens (Picture Books)': 161,
```

And this isn't the most useful. In order to process the data further, I picked the top 15 subgenres and trained my model on those. I exported this dictionary out of my notebook and mapped each subgenre to 1 OR 2 genres out of my list of 15. I then saved it as the genre_key.csv and loaded it into this notebook to convert those genres into tags for modeling.

In [59]: df_key = pd.read_csv('genre_key.csv') # Loading the genre key

In [60]: df_key.replace('', np.nan, inplace=True) # Cleaned up some of the data settings
df_key.replace('None', np.nan, inplace=True)

In [61]: dict_one = dict(zip(df_key['0'], df_key['1'])) # There are two columns, one
dict_two = dict(zip(df_key['0'], df_key['2']))

In [62]: # Creates a list of the unique genre values as long as the values are not a
genre_list = [x for x in df_key['1'].unique() if x == x and x not in ['Adul

In [162]: genre_list

```
Out[162]: ['Fantasy',
 'Romance',
 'Adventure',
 'Dystopia',
 'Paranormal',
 'Space Opera',
 'Aliens',
 'Historical',
 'Space',
 'Time Travel',
 'Speculative',
 'Apocalyptic',
 'War',
 'Mystery',
 'Steampunk',
 'Horror',
 'Queer']
```

Here is how I then created my set of genre tags for each row of the dataframe:

In [64]: def genre_process(x):

```
    """
    Takes the genre list from Goodreads for each row of the dataframe and t
    that will be measured in the final model.

    Parameters
    -------

    x - Dataframe row of df_desc

    Returns
    -------

    A set of unique genres out of the 15 subgenres measured in the final mo
    """

    new_genres = []

    for genre in x:
        if genre != 'None':
            new_genres.append(dict_one[genre])
            new_genres.append(dict_two[genre])

    new_genre_set = set([y for y in new_genres if y==y and y not in ['Adult']

    return new_genre_set
```

In [66]: df_desc['Genre_Set'] = df_desc['genres'].map(lambda x: genre_process(x))

Now that we know which genres each book fits into based on Goodreads users, we can transform our dataframe into a df_genre dataframe for final modeling.

```
In [67]: # Creates a slimmer dataframe with the core, important columns included.  
df_genre = df_desc[[  
    'Book_Title',  
    'Original_Book_Title',  
    'Author_Name',  
    'Edition_Language',  
    'Rating_score',  
    'Rating_votes',  
    'Review_number',  
    'Book_Description',  
    'Year_published',  
    'Age_Group',  
    'genres',  
    'Genre_Set'  
]]
```

```
In [68]: # This column is not used in the final model but it's interesting to consider  
df_genre['Num_Genres'] = df_genre['Genre_Set'].map(lambda x: len(x))
```

And now we can create our target columns, which will take the form of a semi-sparse matrix where each genre column will have a 1 if the book has that genre in its 'genre_set' column and a 0 if it does not. Books can be in all 15 columns, if applicable.

```
In [69]: for genre in genre_list:  
    df_genre[f'{genre}'] = df_genre['Genre_Set'].map(lambda x: 1 if genre i
```

Now we have our final dataframe, so let's check out the first few rows to see what we're dealing with:

In [70]: `df_genre.head()`

Out[70]:

| | Book_Title | Original_Book_Title | Author_Name | Edition_Language | Rating_score | Rating_votes | Rev |
|---|--------------|---------------------|------------------------|------------------|--------------|--------------|-----|
| 0 | Obsidian | Obsidian | Jennifer L. Armentrout | English | 4.17 | 236780 | |
| 1 | Onyx | Onyx | Jennifer L. Armentrout | English | 4.27 | 153429 | |
| 2 | The 5th Wave | The 5th Wave | Rick Yancey | English | 4.03 | 400600 | |
| 3 | The Host | The Host | Stephenie Meyer | English | 3.84 | 915026 | |
| 4 | Opal | Opal | Jennifer L. Armentrout | None | 4.27 | 129006 | |

5 rows × 30 columns

Now we have a better understanding of our genre lists to see how they all shake out:

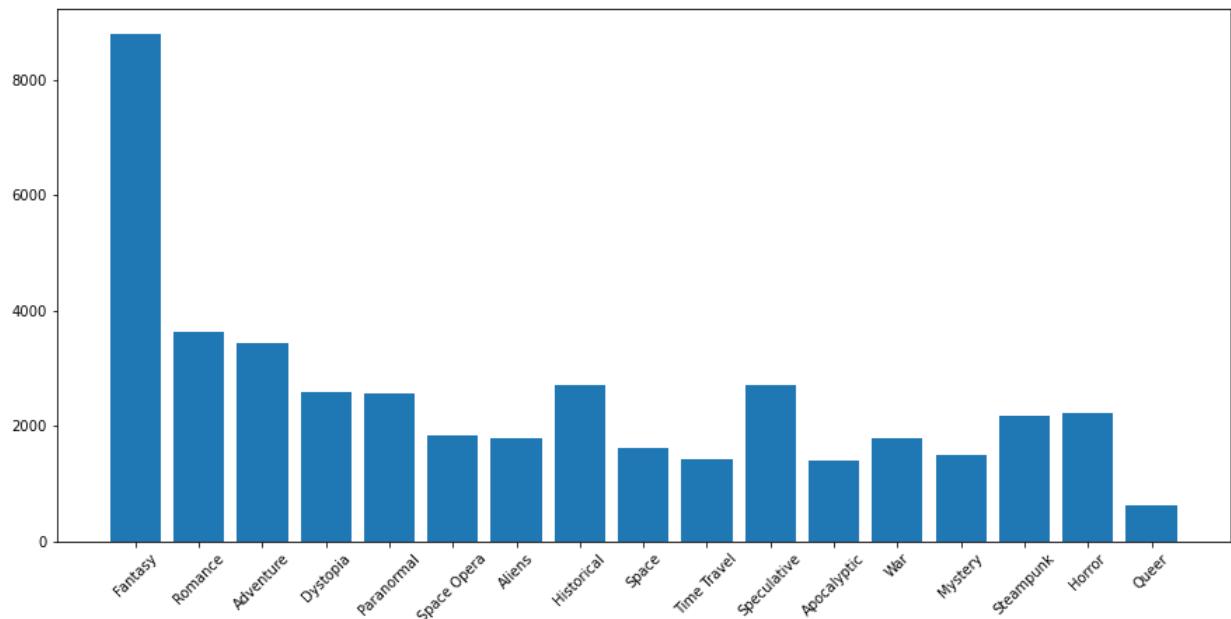
In [71]: `df_genre[genre_list].sum()`

Out[71]:

| | |
|---------------------------|------|
| Fantasy | 8785 |
| Romance | 3623 |
| Adventure | 3445 |
| Dystopia | 2587 |
| Paranormal | 2549 |
| Space Opera | 1831 |
| Aliens | 1795 |
| Historical | 2697 |
| Space | 1610 |
| Time Travel | 1413 |
| Speculative | 2710 |
| Apocalyptic | 1395 |
| War | 1785 |
| Mystery | 1501 |
| Steampunk | 2163 |
| Horror | 2229 |
| Queer | 611 |
| <code>dtype: int64</code> | |

In [72]: # Visualizes the frequency of each subgenre tag

```
plt.figure(figsize=(15,7))
X = df_genre[genre_list].sum().index
y = df_genre[genre_list].sum()
plt.bar(x=X, height=y)
plt.xticks(rotation=45)
plt.title('Frequency of Sub-Genre Tags')
plt.ylabel('Frequency')
plt.xlabel('Sub-Genre')
plt.show()
```



Observations

As we can see, this is a fairly evenly balanced genre list with two clear exceptions:

- **Fantasy** - When it comes down to it, Science Fiction can be considered fantasy to many readers, so it makes sense that about 9000 of the 11000 books have a fantasy classification. This means that any more we build will predict fantasy more often than not. This might not be THAT useful to include as a genre, but it could be helpful to writers who want to ground their work in reality and want to *reduce* their fantasy genre score.
- **Queer** - I would argue a lot of books could be considered queer, but aren't by a general audience. I imagine, over time, this category will expand, but it's likely that it will be overlooked by the algorithm in most cases.

Modeling Genre - Random Forest

When it comes to Multi-Label classification, there aren't a massive number of options for classifiers, so the majority of my focus was on Ensemble Methods, specifically the Random Forest classifier from Sci-Kit Learn. In order to test the various vectorization methods, we have to create new TextSet objects. The only column we are testing is the book description (just like with the Age Model), but the target is now a dataframe, not just a column. I also passed the "multi-label==True" command, to ensure that the target variables are processed correctly.

Once more, I tested multiple vectorization methods on the entire dataset, which you can see below.

```
In [73]: # Creates the Spacy dataset with Spacy vectorization method
spacy_mstop = TextSet(df_genre['Book_Description'],
                      df_genre[genre_list],
                      name='SpaCy_mstop', multi_label=True,
                      is_spacy=True)
```

--- 630.0533187389374 seconds ---

```
In [74]: # Creates the best dataset for the Age Model, TF-IDF with 400 features and
tf_400_2mstop = TextSet(X=df_genre['Book_Description'],
                        y=df_genre[genre_list],
                        name='tf-idf_400_2',
                        is_spacy=False, multi_label=True,
                        keep_stopwords=False)
```

--- 622.1829972267151 seconds ---

```
In [75]: # Creates a 400 feature TF-IDF dataset that only includes 1 word phrases
tf_400_1mstop = TextSet(df_genre['Book_Description'],
                        df_genre[genre_list],
                        name='tf-idf_400_1',
                        is_spacy=False, multi_label=True,
                        keep_stopwords=False)
```

--- 622.322048664093 seconds ---

```
In [76]: # Vectorizes each of the datasets based on the intended parameters
spacy_mstop.vectorize()
tf_400_2mstop.vectorize(max_features=400, ngram_range=(1,2))
tf_400_1mstop.vectorize(max_features=400)
```

```
In [77]: # Combines the datasets for entering into the ModelComparison object
data_mstop = [spacy_mstop, tf_400_2mstop, tf_400_1mstop]
```

Gridsearch and Tuning

For the Random Forest classifier, if you don't pass any parameters, the classifier can fly off the rails with too many estimators and not enough weight placed on each branch. Therefore, I used the Sci-Kit Learn Gridsearch again. I also scaled all of the vectors using the StandardScaler from sklearn. This process takes a long time, but it is a fairly exhaustive exploration of model parameters and dataset usage.

```
In [78]: # The gridsearch that feeds into the ModelComparison object
rf_pipe_genre = Pipeline([('scaler', StandardScaler()), ('rf', RandomForestClassifier())])

grid_genre = {
    'rf__n_estimators': [100, 200], # Decides the number of estimators included
    'rf__criterion' : ['gini','entropy'], # Splits branches based on optimality
    'rf__max_depth': [25, 50, 75], # Determines how extensive and deep the tree can grow
    'rf__min_samples_split': [2, 5], # Determines the minimum number of samples required to split a node
    'rf__min_samples_leaf': [2, 5] # Determines the minimum number of samples required in each leaf node
}

rf_grid_genre = GridSearchCV(rf_pipe_genre, param_grid=grid_genre, scoring='f1_weighted')
rf_compare_genre = ModelComparison(pipeline=rf_grid_genre, data_list=data_main)
```

Metrics

As you may have noticed, I did not optimize Accuracy on this gridsearch. When it comes to multi-label classifiers, accuracy scores can be misleading. Let's say we have 15 columns and the model guesses 14 columns correctly, but 1 column incorrectly...that will return a 'Negative' value rather than a 'Partial Positive'. This means that the accuracy score will be low for a multi-label problem like this. We do have a number of other metrics to measure the model's performance however:

- **Macro** - There are several ways to slice our core metrics. When we look at Macro, the score is taking the Precision/Recall/F1-Score for each genre at a time and then averaging that equally across all genres.
- **Mirco** - This is similar to Macro, however, it doesn't give each genre the same weight. It measures the individual contributions of each genre to calculate the overall metric. Neither Macro nor Micro is *better* but they give a different understanding of what's happening on a row by row basis
- **F1-Samples** - This calculates the F1-Score for each individual row and then averages them. This is specifically designed for Multi-Label classification
- **Hamming Loss** - This is the most effective replacement for Accuracy Score on multi-label classification. It measures the number of incorrectly attributed labels. The lower the score, the higher the overall accuracy.

Ultimately, I selected **F1-Samples** as the optimized metric because it seems to be the best balance across all of the major metrics. So, with that overview, let's see how the model did!

What is Good?

With multi-label models, it's much harder to say what 'good' is. As you will see, a lot of the results in the end are subjective, but also useful. I will use this initial model with the three datasets as my baseline to work from to see if we can increase metrics.

In [79]: `rf_compare_genre.fit_models()
rf_compare_genre.score_comparison`

```
SpaCy_mstop finished in 3271.1978089809418 seconds
tf-idf_400_2 finished in 1196.275650024414 seconds
tf-idf_400_1 finished in 1194.1586890220642 seconds
--- 5662.013308763504 seconds to process ---
```

Out[79]:

| | SpaCy_mstop Test | tf-idf_400_2 Test | tf-idf_400_1 Test |
|--------------------------|------------------|-------------------|-------------------|
| Accuracy | 0.013100 | 0.037622 | 0.035942 |
| Precision (Macro) | 0.302195 | 0.778495 | 0.786072 |
| Precision (Micro) | 0.785547 | 0.824558 | 0.830730 |
| Recall (Macro) | 0.101155 | 0.199296 | 0.200397 |
| Recall (Micro) | 0.260873 | 0.335124 | 0.336337 |
| F1 (Micro) | 0.391675 | 0.476560 | 0.478816 |
| F1 (Macro) | 0.110665 | 0.272092 | 0.274833 |
| F1 (Samples) | 0.375085 | 0.448149 | 0.450294 |
| Hamming-Loss | 0.184809 | 0.167895 | 0.166986 |

In [80]: `rf_compare_genre.calc_scores(data_type='holdout')
rf_compare_genre.score_comparison`

Out[80]:

| | SpaCy_mstop Holdout | tf-idf_400_2 Holdout | tf-idf_400_1 Holdout |
|--------------------------|---------------------|----------------------|----------------------|
| Accuracy | 0.019039 | 0.049864 | 0.051677 |
| Precision (Macro) | 0.297912 | 0.736465 | 0.735102 |
| Precision (Micro) | 0.782790 | 0.826257 | 0.833147 |
| Recall (Macro) | 0.107021 | 0.212808 | 0.214823 |
| Recall (Micro) | 0.268699 | 0.352311 | 0.354455 |
| F1 (Micro) | 0.400071 | 0.493988 | 0.497326 |
| F1 (Macro) | 0.117742 | 0.290495 | 0.295099 |
| F1 (Samples) | 0.382771 | 0.466272 | 0.469038 |
| Hamming-Loss | 0.180417 | 0.161591 | 0.160418 |

Observations

The differences between TF-IDF and SpaCy vectorizations is obvious. TF-IDF data definitely performed better in every aspect compared to SpaCy. When it comes to whether or not the 1 word phrase the 1 or 2 word phrase vectorizations didn't make a massive difference. As I mentioned

above, the overall 'accuracy' score is miserably bad, which is to be expected. However, a Hamming Loss of less than .2 is not too bad!

Genre Model - Part 2 - Popular Only

Now that we have an initial baseline of scores to measure against, let's see if we can increase our overall accuracy/lower our Hamming Loss scores. First, let's restrict our data to popular only. I will remove the 25% of rows with the fewest number of reviews. Some of these books are extremely esoteric, or are collections with messy descriptions. Let's see if we can beat a Hamming Loss score of .1604

I was originally going to narrow my dataset to only popular novels, but that is a double edged sword. The best measure of popularity on this dataset would be the number of reviews/scores a book received. That said, this might be a specific edition of a famous novel, also books published in the last year almost certainly would have a popularity disadvantage.

```
In [81]: df_genre['Review_number'].describe()
```

```
Out[81]: count      11025.000000
          mean      1355.155193
          std       5403.296914
          min       0.000000
          25%      55.000000
          50%     163.000000
          75%     597.000000
          max     174079.000000
          Name: Review_number, dtype: float64
```

```
In [82]: df_pop = df_genre[df_genre['Review_number'] >= 55] # Removed the bottom 25%
```

```
In [83]: # The Spacy dataset, but with the reduced number of rows
spacy_mstop_p = TextSet(df_pop['Book_Description'],
                       df_pop[genre_list],
                       name='Spacy_mstop', multi_label=True,
                       is_spacy=True)
```

--- 483.79224586486816 seconds ---

```
In [84]: # The TF-IDF dataset with 1-2 word phrases
tf_400_2mstop_p = TextSet(x=df_pop['Book_Description'],
                          y=df_pop[genre_list],
                          name='tf-idf_400_2',
                          is_spacy=False, multi_label=True,
                          keep_stopwords=False)
```

--- 481.70191407203674 seconds ---

```
In [85]: # The TF-IDF dataset with 1 word phrases
tf_400_1mstop_p = TextSet(df_pop['Book_Description'],
                           df_pop[genre_list],
                           name='tf-idf_400_1',
                           is_spacy=False, multi_label=True,
                           keep_stopwords=False)
```

--- 486.6696741580963 seconds ---

```
In [86]: # As always, we have to vectorize
spacy_mstop_p.vectorize()
tf_400_2mstop_p.vectorize(max_features=400, ngram_range=(1,2))
tf_400_1mstop_p.vectorize(max_features=400)
```

```
In [87]: # Our new data list
data_mstop_p = [spacy_mstop_p, tf_400_2mstop_p, tf_400_1mstop_p]
```

```
In [88]: # We're using the same gridsearch pipeline to compare against the last result
rf_pipe_genre_p = Pipeline([('scaler', StandardScaler()), ('rf', RandomForestClassifier())])

grid_genre = {
    'rf__n_estimators': [100, 200],
    'rf__criterion' : ['gini', 'entropy'],
    'rf__max_depth' : [25, 50, 75],
    'rf__min_samples_split': [2, 5],
    'rf__min_samples_leaf': [2, 5]
}

rf_grid_genre_p = GridSearchCV(rf_pipe_genre_p, param_grid=grid_genre, scoring='accuracy')
rf_compare_genre_p = ModelComparison(pipeline=rf_grid_genre_p, data_list=data_mstop_p)
```

In [89]: rf_compare_genre_p.fit_models()
rf_compare_genre_p.score_comparison

```
SpaCy_mstop finished in 2378.7598679065704 seconds
tf-idf_400_2 finished in 910.8403558731079 seconds
tf-idf_400_1 finished in 904.592137336731 seconds
--- 4194.499955892563 seconds to process ---
```

Out[89]:

| | SpaCy_mstop Test | tf-idf_400_2 Test | tf-idf_400_1 Test |
|--------------------------|------------------|-------------------|-------------------|
| Accuracy | 0.012923 | 0.040553 | 0.042335 |
| Precision (Macro) | 0.337049 | 0.808658 | 0.808453 |
| Precision (Micro) | 0.817664 | 0.861001 | 0.858714 |
| Recall (Macro) | 0.108641 | 0.229523 | 0.235643 |
| Recall (Micro) | 0.278731 | 0.374987 | 0.379087 |
| F1 (Micro) | 0.415741 | 0.522439 | 0.525977 |
| F1 (Macro) | 0.119212 | 0.310378 | 0.316248 |
| F1 (Samples) | 0.411757 | 0.504137 | 0.506624 |
| Hamming-Loss | 0.190311 | 0.166536 | 0.165985 |

In [90]: rf_compare_genre_p.calc_scores(data_type='holdout')
rf_compare_genre_p.score_comparison

Out[90]:

| | SpaCy_mstop Holdout | tf-idf_400_2 Holdout | tf-idf_400_1 Holdout |
|--------------------------|---------------------|----------------------|----------------------|
| Accuracy | 0.015644 | 0.031288 | 0.028881 |
| Precision (Macro) | 0.281499 | 0.721212 | 0.624428 |
| Precision (Micro) | 0.809563 | 0.854496 | 0.855219 |
| Recall (Macro) | 0.113382 | 0.210002 | 0.217455 |
| Recall (Micro) | 0.277558 | 0.351894 | 0.358960 |
| F1 (Micro) | 0.413387 | 0.498498 | 0.505674 |
| F1 (Macro) | 0.123967 | 0.280147 | 0.286796 |
| F1 (Samples) | 0.408204 | 0.481065 | 0.487719 |
| Hamming-Loss | 0.197282 | 0.177320 | 0.175763 |

Observations

Here our holdout Hamming Loss scores are higher than with the full dataset, so there was an overall drop in accuracy. This is interesting because it could be due to 2 things: 1) the smaller dataset will produce weaker results or 2) there popular books are a little harder to fit into genre categories. Let's attempt one final comparison.

Genre Model - Part 3 - Recent Books

Last, let's see if we can reduce our Hamming Loss by restricting our dataset to books released in the last 10 years. This will almost halve our dataset, which could definitely cause issues. However, let's give it a shot and see what happens.

```
In [91]: # Slices the dataframe to only include books released on or after 2010.
df_g_recent = df_genre[df_genre['Year_published'] >= 2010]
```

```
In [92]: len(df_g_recent)
```

```
Out[92]: 6848
```

As we can see, this reduces our dataset by 40%, which is not ideal, but let's see if it affects our model's accuracy in a positive way. As always, we have to create our datasets, which will be the same as the previous ones but with the reduced dataframe rows.

```
In [93]: spacy_mstop_n = TextSet(df_g_recent['Book_Description'],
                           df_g_recent[genre_list],
                           name='SpaCy_mstop', multi_label=True,
                           is_spacy=True)
```

```
--- 424.83809900283813 seconds ---
```

```
In [94]: tf_400_2mstop_n = TextSet(x=df_g_recent['Book_Description'],
                           y=df_g_recent[genre_list],
                           name='tf-idf_400_2',
                           is_spacy=False, multi_label=True,
                           keep_stopwords=False)
```

```
--- 427.0953722000122 seconds ---
```

```
In [95]: tf_400_1mstop_n = TextSet(df_g_recent['Book_Description'],
                           df_g_recent[genre_list],
                           name='tf-idf_400_1',
                           is_spacy=False, multi_label=True,
                           keep_stopwords=False)
```

```
--- 422.80571699142456 seconds ---
```

```
In [96]: data_mstop_n = [spacy_mstop_n, tf_400_2mstop_n, tf_400_1mstop_n]
```

```
In [97]: # And we also need to vectorize
spacy_mstop_n.vectorize()
tf_400_2mstop_n.vectorize(max_features=400, ngram_range=(1,2))
tf_400_1mstop_n.vectorize(max_features=400)
```

```
In [98]: # We are using the same gridsearch as the last few attempts.
rf_pipe_genre_n = Pipeline([('scaler', StandardScaler()), ('rf', RandomForestClassifier())])

grid_genre = {
    'rf__n_estimators': [100, 200],
    'rf__criterion' : ['gini','entropy'],
    'rf__max_depth': [25, 50, 75],
    'rf__min_samples_split': [2, 5],
    'rf__min_samples_leaf': [2, 5]
}

rf_grid_genre_n = GridSearchCV(rf_pipe_genre_n, param_grid=grid_genre, scoring='accuracy')
rf_compare_genre_n = ModelComparison(pipeline=rf_grid_genre_n, data_list=dataset)
```

```
In [99]: # Let's fit and compare scores
rf_compare_genre_n.fit_models()
rf_compare_genre_n.score_comparison
```

SpaCy_mstop finished in 1879.7316989898682 seconds
tf-idf_400_2 finished in 758.3343238830566 seconds
tf-idf_400_1 finished in 759.7690949440002 seconds
--- 3398.0786621570587 seconds to process ---

Out[99]:

| | SpaCy_mstop Test | tf-idf_400_2 Test | tf-idf_400_1 Test |
|--------------------------|------------------|-------------------|-------------------|
| Accuracy | 0.016225 | 0.047052 | 0.047593 |
| Precision (Macro) | 0.359448 | 0.802213 | 0.799538 |
| Precision (Micro) | 0.755937 | 0.801820 | 0.805058 |
| Recall (Macro) | 0.114793 | 0.249161 | 0.252280 |
| Recall (Micro) | 0.279670 | 0.381184 | 0.382941 |
| F1 (Micro) | 0.408288 | 0.516720 | 0.519007 |
| F1 (Macro) | 0.122766 | 0.328360 | 0.332595 |
| F1 (Samples) | 0.379619 | 0.476000 | 0.479968 |
| Hamming-Loss | 0.190787 | 0.167817 | 0.167054 |

```
In [100]: # Here we can compare the holdout scores as well
rf_compare_genre_n.calc_scores(data_type='holdout')
rf_compare_genre_n.score_comparison
```

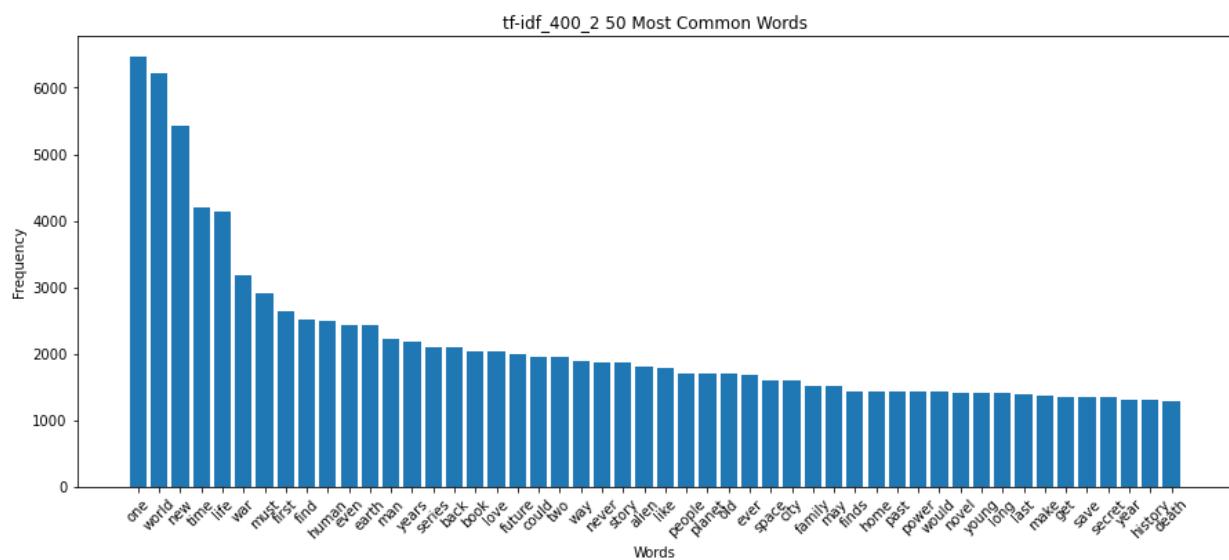
Out[100]:

| | SpaCy_mstop Holdout | tf-idf_400_2 Holdout | tf-idf_400_1 Holdout |
|--------------------------|---------------------|----------------------|----------------------|
| Accuracy | 0.016058 | 0.030657 | 0.032117 |
| Precision (Macro) | 0.209220 | 0.753390 | 0.718425 |
| Precision (Micro) | 0.778744 | 0.804917 | 0.807031 |
| Recall (Macro) | 0.118547 | 0.232121 | 0.237778 |
| Recall (Micro) | 0.292984 | 0.368957 | 0.375500 |
| F1 (Micro) | 0.425779 | 0.505982 | 0.512528 |
| F1 (Macro) | 0.126730 | 0.308331 | 0.315416 |
| F1 (Samples) | 0.396632 | 0.465277 | 0.473573 |
| Hamming-Loss | 0.186690 | 0.170202 | 0.168742 |

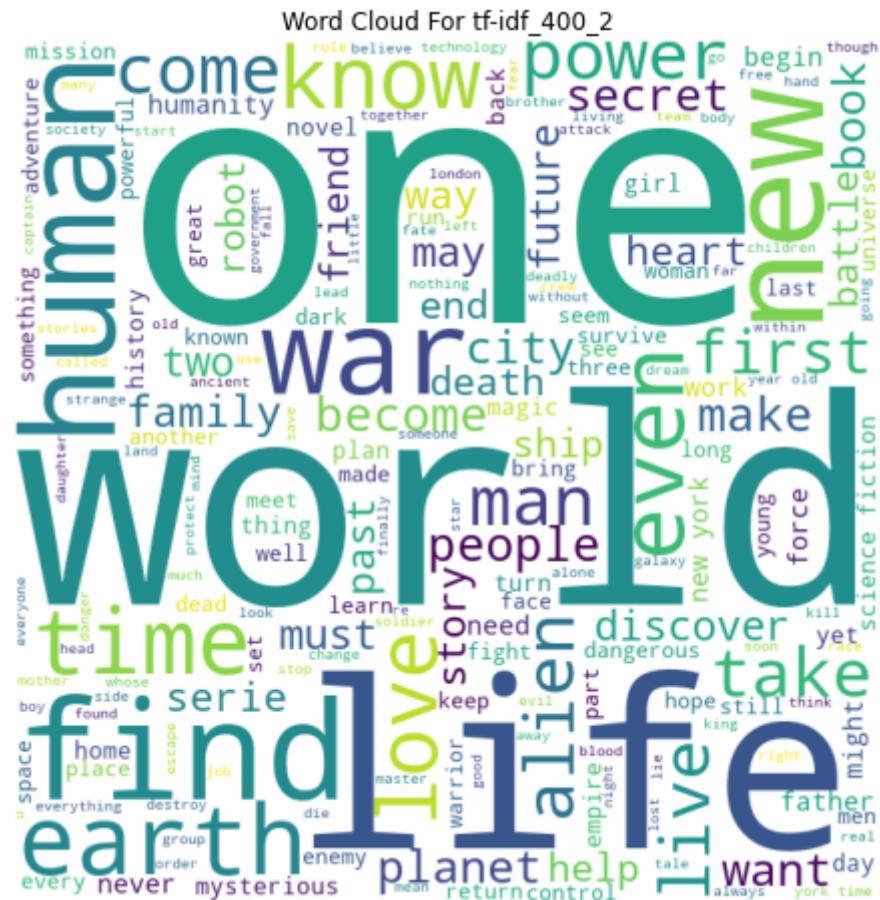
Observations

This one didn't do too badly! It seems as though there is more commonality between newer books than there is among 'popular' books. That said, the original dataset with all 11k rows was more accurate and produced a slightly better Hamming Loss score. Therefore, our final model will be trained on the full dataset with the TF-IDF vectorization method. As a reminder, here is the frequency plot of that dataset and the word cloud:

```
In [101]: tf_400_2mstop.plot_frequency()
```



```
In [102]: tf_400_2mstop.word_cloud()
```



We will also save this vectorizer for later transformations

```
In [103]: # Saves vectorizer for future use.  
genre_vectorizer = tf_400_2mstop.vectorizer
```

In order to export our final trained model, we need to retrain it only on the best dataset, which is the TF-IDF_400_2 dataset.

```
In [104]: rf_pipe_final = Pipeline([('scaler', StandardScaler()), ('rf', RandomForestClassifier())])

grid_final = {
    'rf__n_estimators': [100, 200],
    'rf__criterion' : ['gini','entropy'],
    'rf__max_depth': [25, 50, 75],
    'rf__min_samples_split': [2, 5],
    'rf__min_samples_leaf': [2, 5]
}

rf_grid_final = GridSearchCV(rf_pipe_final, param_grid=grid_final, scoring='f1_weighted')

rf_compare_final = ModelComparison(
    pipeline=rf_grid_final,
    data_list=[tf_400_2mstop],
    y_format='multi_label',
    name='rf_final')
```

```
In [105]: rf_compare_final.fit_models()
rf_compare_final.all_scores
```

tf-idf_400_2 finished in 1198.602403640747 seconds
--- 1198.7354109287262 seconds to process ---

Out[105]:

| | tf-idf_400_2 Train | tf-idf_400_2 Test |
|--------------------------|--------------------|-------------------|
| Accuracy | 0.280346 | 0.038965 |
| Precision (Macro) | 0.989416 | 0.784374 |
| Precision (Micro) | 0.945551 | 0.829003 |
| Recall (Macro) | 0.575053 | 0.201671 |
| Recall (Micro) | 0.683982 | 0.337290 |
| F1 (Micro) | 0.793774 | 0.479493 |
| F1 (Macro) | 0.689561 | 0.275266 |
| F1 (Samples) | 0.746391 | 0.449915 |
| Hamming-Loss | 0.081243 | 0.167006 |

```
In [106]: genre_model = rf_compare_final.pipeline
```



Readyng the Models for Deployment

Now that we have our age and our genre models, we need to do a few things to create the functions we need to deploy this on Streamlit. I have saved both models to this repo folder for use elsewhere, but before we just start throwing book descriptions into the mix, we have to build a preprocessing pipeline. Also, we want the results of the model's predictions to be informative. Because of this, the actual labels the model spits out won't be as helpful as the ranked probabilities of each genre. This way, an author can increase and decrease their scores by removing and adding specific words.

A Note on TF-IDF

For any author reading this looking to use it on their own work, please take note that this model does not account for sentence structure, unique words (like proper nouns etc.) but rather just the language that exists in certain descriptions and not in others. Therefore, you could artificially increase your military score by just dumping the words "War", "soldier", "gun" etc. without any context. This model doesn't tell you if your description is GOOD, only what the model believes which genre it belongs to.

Building a Pre-Processing Pipeline

With any textual input, we need to vectorize the data in exactly the same way we vectorized the text that fed the trained model. The `TextSet` class that I created stores the vectorization (trained on the entire book description corpus) and we can store that for future use. We must also tokenize the text in the same way using the `'process_text()'` function to ensure that we are lemmatizing the words in the same manner as the test data. To do so, we need to build several functions to output results that are helpful to an author.

Below you can see the `create_tf_vector` function as well as a `print_scores` function

```
In [58]: def create_tf_vector(description, model='genre'):  
    """  
    Uses the process_text function to pre-process a book description in order  
    to create a vector.  
  
    Parameters  
    -----  
  
    description - string - a book description that we want to analyze in the  
    model - string - "genre", "age" - determines which vectorizer to use, etc.  
  
    Returns  
    -----  
  
    A vectorized representation of the text as an numpy array  
    """  
  
    if model == 'genre':  
        vectorizer = genre_vectorizer  
    elif model == 'age':  
        vectorizer = age_vectorizer  
  
    description.replace('\n', '') # Removes any superfluous line breaks  
    tokens = process_text(description, keep_stopwords=False) # Removes stop words  
    vector = vectorizer.transform([' '.join(tokens)]) # Turns the tokens into vectors  
  
    return vector.toarray()
```

```
In [59]: def print_scores(description, mode='genre'):

    ...

    Prints the results of either the genre or the age model when a book des
    The function preprocesses the description with a vectorizer based on wh
    feeds that vector into either the genre or age model, returning the res
    results as probabilities and sorted by value.

    Parameters
    -----
    description - string - a book description that we want to analyze in th
    model - string - "genre", "age" - determines which vectorizer to use, e

    Returns
    -----
    A dataframe of the scores, listed in descending order based on probabil
    ...

    if mode == 'genre':
        labels = genre_list # Uses the list of genres that were used to tra
        model = genre_model
    elif mode == 'age':
        labels = ['Adult', 'Children', 'Young Adult']
        model = age_model

    # Vectorizes the description and then creates prediction probabilities
    vector = create_tf_vector(description, model=model)
    predict = model.predict_proba(vector)

    # Creates score dictionary that will be turned into a dataframe
    score_dict = {}

    if mode == 'genre':
        for (n, label) in enumerate(labels):
            score_dict[label] = predict[n][0][1] #The outputs of each model

    elif mode == 'age':
        for (n, label) in enumerate(labels):
            score_dict[label] = predict[0][n]

    # Sorts the dictionary based on score values
    final_dict = {k: v for k, v in sorted(score_dict.items(), key=lambda it

    # Turns dictionary into a dataframe
    df = pd.DataFrame.from_dict([final_dict]).T

    df.columns = ['Probabilities']

    return df
```

Now that we have both of these, let's test it. I figured the best way to test the effectiveness of the program is to feed in my own work and see what happens! I have three book descriptions along

with my thoughts on their age categories as well as their subgenres in the science fiction space.

- **Septimus Salt** - A fantasy novel intended for young adults. Has some romantic elements, but it's mainly a seafaring adventure story.

```
In [109]: septimus = '''In Septimus Salt, a boy grows from adolescence and into old age. The impossible: to sail to the moon. Eventually, he is forced to come to terms with the reality that his dream may never come to pass and that he might have thrown his life away chasing a mirage. Should he give up and head back? Or do you just keep sailing into the storm and hope one man's life, from humble beginnings on the island of Evermore in the Infirmary, will lead him to success? He follows in the footsteps of great sailors who completely unaware of the myriad dangers that await him in the lonely water, the sea, love, monsters in the dark, and the sea itself (as well as some goop that turns him into a fish). The story begins in the Young Adult vein of The Little Prince or A Wrinkle in Time, but as his adventures grow darker and more sinister, the story falls into the whimsical realm of Susanna Clarke.'''
```

- **Arcadium** - A tense, science-fiction political thriller. Definitely for adults.

```
In [110]: arcadium = '''Arcadium I is the science fiction retelling of Shakespeare's  
It tells the story of the ascension of an underestimated ruler by way of br  
and strategic brilliance. Five hundred years after humans have fled a deca  
on two planets in a solar system: the jungle planet Arcadia and an ice plan  
plagued with income inequality, terrorist attacks, political strife, and fa  
under the heel of the technologically superior Avalon, forced to send shipm  
whenever the planets fall into a similar orbit. If the shipments don't come  
always wins. Helyn Pilot is second in line for the Arcadian throne. She's b  
but utterly under-utilized by her family as a vapid tabloid target. At 22 y  
as little more than a party girl whose closest relationship is with her dru  
night club owner, Jack Stafford. Her addictions and her reputation destroy  
the Avalonian heir and with it, their only chance for peace. In the explosi  
into the darkest jungles and is forced to fight her way out. Enemies and es  
from terrorist groups and Avalonian agents. Though experiencing serious dru  
thrives, and manipulates her enemies' misconceptions of her in order to pol  
out-maneuver them at every turn. Arcadium I is the first part of a trilogy  
of Shakespeare's Henriad, culminating in the massive and all-out invasion d
```

- **Winterland** - An apocalyptic, gory horror story set in Chicago. Very much for adults.

```
In [111]: winterland = '''
```

Kat Dobson is a millennial lost between her loyalty to revolutionary politics as she enters her thirties. Newly sober, she takes her yearly pilgrimage to the suburb of Chicago only to face the brunt of her family's conservative politics. It is a drunken, emotional disaster. Afterwards, Kat realizes she's sitting on the edge of her values for a paycheck. But before she can take the plunge to become a member of the party, the morning after the dinner, the sun doesn't come up. The Dobson's phones continue to fall, trapping them all inside her family home. One by one, the family members start to fall ill. Panic sets in as the sun fails to rise again, but the truth is that lies in wait beyond their walls: an unrelenting cabal of psychotic humans. One by one, the family members are taken away, leaving Kat alone in apocalyptic Chicago. In the fight for her life, Kat has to wrestle with the realization that the world has changed and the old rules she took for granted are the very things that will get her killed. Will she find a new reality, or will she succumb to the sickness and become one of the monsters?

Let's see how the model does on each of these descriptions!

Septimus Salt

- Fantasy, Adventure, Romance
- Young Adult

```
In [112]: print_scores(septimus, mode='genre')
```

Out[112]:

| Probabilities | |
|--------------------|----------|
| Fantasy | 0.886850 |
| Romance | 0.665305 |
| Paranormal | 0.417075 |
| Historical | 0.365290 |
| Dystopia | 0.298736 |
| Time Travel | 0.285788 |
| Adventure | 0.269747 |
| Speculative | 0.212134 |
| Horror | 0.188773 |
| Steampunk | 0.161618 |
| Apocalyptic | 0.161226 |
| Mystery | 0.142959 |
| Queer | 0.107469 |
| Aliens | 0.043323 |
| War | 0.022926 |
| Space | 0.021877 |
| Space Opera | 0.015775 |

```
In [113]: print_scores(septimus, mode='age')
```

Out[113]:

| Probabilities | |
|--------------------|----------|
| Adult | 0.556962 |
| Young Adult | 0.334044 |
| Children | 0.108994 |

Not perfect, but it definitely reveals a few things. The Fantasy score is very high, which is good, because Septimus Salt is more fantasy than Science Fiction. Romance scored high, which is also good. It's not a 'romance' novel at its essence but a love story is central to its plot. Paranormal and Historical are both interesting selections, perhaps because sailing is heavily involved. As for age scores, it believes it's adult, but with only 55%, while young adult is definitely up there. Let's try another!

Arcadium

- Science Fiction, Space, War, Speculative
- Adult

```
In [114]: print_scores(arcadium, mode='genre')
```

Out[114]:

| Probabilities | |
|--------------------|----------|
| Fantasy | 0.791913 |
| Adventure | 0.364713 |
| Space Opera | 0.362963 |
| Space | 0.357648 |
| Aliens | 0.329401 |
| War | 0.308813 |
| Speculative | 0.278885 |
| Dystopia | 0.205038 |
| Romance | 0.161866 |
| Steampunk | 0.152668 |
| Horror | 0.151029 |
| Mystery | 0.124797 |
| Historical | 0.110081 |
| Apocalyptic | 0.105333 |
| Paranormal | 0.097650 |
| Queer | 0.034167 |
| Time Travel | 0.026540 |

```
In [115]: print_scores(arcadium, mode='age')
```

Out[115]:

| Probabilities | |
|--------------------|----------|
| Adult | 0.839645 |
| Young Adult | 0.149596 |
| Children | 0.010759 |

Now we can see the differences starting to show. Arcadium is solidly in the 'Adult' category, which is great. It's also cool that it picks up that Arcadium is speculative, because while it is a science-fiction book, it tries to be rooted in reality. Space Opera, Adventure and Space were also high on the list, which makes sense give how much 'space' language I have in the description. Let's attempt our final description:

Winterland

- Dark Fantasy, Apocalyptic, Horror
- Adult

```
In [116]: print_scores(winterland, mode='genre')
```

Out[116]:

| Probabilities | |
|--------------------|----------|
| Fantasy | 0.748552 |
| Dystopia | 0.656224 |
| Apocalyptic | 0.600070 |
| Horror | 0.510428 |
| Adventure | 0.363222 |
| Romance | 0.331423 |
| Paranormal | 0.223372 |
| Steampunk | 0.130586 |
| Mystery | 0.122560 |
| War | 0.112097 |
| Historical | 0.101232 |
| Speculative | 0.093751 |
| Queer | 0.061169 |
| Aliens | 0.060103 |
| Time Travel | 0.055994 |
| Space | 0.023024 |
| Space Opera | 0.022561 |

```
In [117]: print_scores(winterland, mode='age')
```

Out[117]:

| Probabilities | |
|--------------------|----------|
| Adult | 0.566544 |
| Young Adult | 0.382402 |
| Children | 0.051054 |

These results are also very curious. It definitely latches onto the apocalyptic aspect of the story (which might be cheating because I literally include the word 'apocalyptic' in the description) but it also scores very high on 'Dystopia' which I wouldn't have guessed. Horror also scored high, which is fantastic. As for age scores, at least the model knows this isn't for children, but the Young Adult score is higher than expected.

Book Similarity

Now that we can identify the genres, let's see if we can find similar books to our description. To do this I will use Sci-Kit Learn's **cosine_similarity** function. I use this because, if the vectorization method I selected is indeed the most effective available, the best way to determine the similarity

between two vectors is with the cosine distance. I made this decision after exploring the benefits of cosine distance in building the Skip-Gram algorithm at the core of SpaCy and other word embedding libraries. Fortunately, the computational requirements to evaluate cosine similarity are fairly low.

First, we need to vectorize every book description, which we can do with our vectorizer function:

```
In [119]: df_genre['TF_Vector'] = df_genre['Book_Description'].map(lambda x: create_t
```

```
In [121]: # Creates a slimmer Dataframe which includes all vectorizations of each book
df_vectors = df_genre[[
    'Book_Title',
    'Author_Name',
    'Year_published',
    'Book_Description',
    'TF_Vector',
    'Rating_votes',
    'Review_number',
    'Rating_score',
    'Age_Group']]
```

And here is the function that does all the work to process and organize the dataframe:

```
In [52]: def find_most_similar(description, number=10, year=1900, detail=None):
    """
    Takes a book description, processes it into a vector and returns the most
    similarity of that vector to the other book descriptions. Can return si
    Parameters
    -----
    description - string - a book description that we want to analyze in th
    number - int - determines the number of rows returned in the final data
    year - int - restricts the comparisons to books published after a certa
    detail - None or int - if None is passed, the return will be a datafram
    Returns
    -----
    A dataframe ordered by the cosine similarity of the book descriptions.
    then the return will be the dataframe as well as the book description o
    ...
    df = df_vectors[df_vectors['Year_published'] >= year] # Reduces the fin
    vector = create_tf_vector(description, model='genre') #vectorizes your
    # We find the cosine similarity score for each vector in the dataframe
    df['Similarity'] = df['TF_Vector'].map(lambda x: cosine_similarity(vect
    # The final dataframe is sorted by similarity scores
    df_final = df.sort_values(by=['Similarity'], ascending=False)

    # Drops unwanted columns
    df_final.drop(columns=['TF_Vector'], inplace=True)

    if detail == None:
        return df_final.head(number) # If detail is not requested, returns
    else: #If detail IS requested, it will print off one description for cl
        title = df_final['Book_Title'].iloc[detail]
        author = df_final['Author_Name'].iloc[detail]
        year = df_final['Year_published'].iloc[detail]
        desc = df_final['Book_Description'].iloc[detail]

        print(f'''
        Most similar #{detail+1}:
        Title: {title}    Author: {author}    Year: {year}
        {desc}
        ''')
    return df_final
```

```
In [51]: def most_impactful_words(description, num=None):  
    ...  
    Finds the most impactful words in a description. It vectorizes the desc  
    of vector magnitude.  
  
    Parameters  
    -----  
  
    description - string - the book description that you would like to anal  
    num - int - number of features you would like to see. Defaults to all r  
            If an integer greater than the number of words is passed, t  
  
    Returns  
    -----  
  
    A dataframe showing the words in order of importance  
    ...  
  
    # Vectorizes the description using the genre vectorizer  
    vector = create_tf_vector(description)  
    # Gets the names of the vector columns which correspond to the 400 most  
    words = genre_vectorizer.get_feature_names()  
  
    # Turns the vector into a dataframe with the words as the index  
    df = pd.DataFrame(vector, columns = words).T  
    df.columns = ['Value']  
  
    # Returns the words ranked in order of score and filters out any words  
    final_df = df[df['Value'] > 0].sort_values(by='Value', ascending=False)  
  
    # Returns the number of words requested, defaults to all  
    if (num == None) or (num >= len(final_df)):  
        return final_df  
    else:  
        return final_df.head(num)
```

Now, simply, we just need to run the vectorized book description against the vectors in the dataset and then order them in terms of similarity. Here's what we find for each book:

In [130]: `find_most_similar(septimus, detail=0)`

Most similar #1:

Title: Clockwork Author: Philip Pullman Year: 1996

Fritz, the writer, spins a spine-tingling tale to cheer up Karl, the apprentice clockmaker. But rather than helping matters, the story begins to come true.... The stories of Karl, the apprentice; Dr. Kalmenius, his nefarious "savior"; Gretl, the brave daughter of the town innkeeper; and a young prince whose clockwork heart is in danger of winding down come together in surprising and magical ways in a story that has the relentless urgency of a ticking clock.

Out[130]:

| | Book_Title | Author_Name | Year_published | Book_Description | Rating_votes | Review_number |
|-------|-------------------------------------|-------------------|----------------|--|--------------|---------------|
| 9531 | Clockwork | Philip Pullman | 1996 | Fritz, the writer, spins a spine-tingling tale... | 6753 | 725 |
| 11077 | The Lost Prince | Selden Edwards | 2012 | From the author of the beloved New York Times ... | 692 | 147 |
| 418 | Once Upon a Time | Alessandra Hazard | 2019 | A very proper prince and a rude, dangerous man... | 2395 | 303 |
| 1235 | Devilish Dot | Jaid Black | 2004 | Book 6.5 in the Trek Mi Q'an Series. Dorothy "... | 1004 | 28 |
| 867 | From a Distant Star | Karen McQuestion | 2015 | Seventeen-year-old Emma was the only one who h... | 2422 | 532 |
| ... | ... | ... | ... | ... | ... | ... |
| 7256 | Ghost | John Ringo | 2005 | Retired after 15 years in special ops due to a... | 4093 | 218 |
| 7254 | Pandora's Legions | Christopher Anvil | 2002 | The mighty Centran Empire had been conquering ... | 1194 | 28 |
| 1564 | Grantville Gazette III | Eric Flint | 2006 | Stories include: * Postage Due by Eric Flint* P... | 604 | 19 |
| 8915 | Return of the Jedi | James Kahn | 1983 | Der letzte Teil der Star Wars Saga erzählt die... | 9251 | 260 |
| 8375 | Gunnerkrigg Court, Volume 5: Refine | Thomas Siddell | 2015 | The fifth volume in the ever-popular Gunnerkri... | 719 | 36 |

10973 rows × 9 columns

When this first description came back, I was super excited. Not only is Philip Pullman one of my favorite authors of all time, but *Clockwork* doesn't seem to have a direct link to *Septimus Salt* but both share a whimsical, magical and dark tone. That is exactly the kind of the connection I'm looking to build with this program. I don't want a carbon copy of some kid sailing a lot, I'm looking for tonal and thematic similarities instead.

Again, this is not machine learning, though it is vectorized based on training a machine learning model. This is not meant to be a definitive link between two books, but it's intended to help in the search for similar authors and books, which can be valuable to any new author.



Conclusion

These two models could be extremely helpful to new science fiction authors in trying to refine and improve their book descriptions. It could also help them identify other similar books and authors to help young writers research possible agents to submit their work to. There are many uses for this information, but the program has many shortcomings in terms of assessing 'successful' descriptions. Here are the two main use cases for a possible science fiction book:

Use Case 1 - Refine Description

As you saw before, my description of Arcadium received the following scores and important words:

```
In [131]: print_scores(arcadium, mode='genre')
```

Out[131]:

| Probabilities | |
|--------------------|----------|
| Fantasy | 0.791913 |
| Adventure | 0.364713 |
| Space Opera | 0.362963 |
| Space | 0.357648 |
| Aliens | 0.329401 |
| War | 0.308813 |
| Speculative | 0.278885 |
| Dystopia | 0.205038 |
| Romance | 0.161866 |
| Steampunk | 0.152668 |
| Horror | 0.151029 |
| Mystery | 0.124797 |
| Historical | 0.110081 |
| Apocalyptic | 0.105333 |
| Paranormal | 0.097650 |
| Queer | 0.034167 |
| Time Travel | 0.026540 |

```
In [132]: print_scores(arcadium, mode='age')
```

Out[132]:

| Probabilities | |
|--------------------|----------|
| Adult | 0.839645 |
| Young Adult | 0.149596 |
| Children | 0.010759 |

In [144]: `most_impactful_words(arcadium, 10)`

Out[144]:

| | Value |
|------------------|----------|
| planet | 0.281074 |
| political | 0.267651 |
| two | 0.257302 |
| years | 0.247894 |
| forced | 0.234755 |
| enemies | 0.234265 |
| part | 0.233458 |
| every | 0.200372 |
| way | 0.171648 |
| jack | 0.144536 |

This is actually an old book description for a previous draft. After rewriting the book, with several character and thematic shifts, I created a new book description:

In [47]: `arcadium_2 = ''`

```
Nobody has ever taken Helyn Pilot seriously. As the daughter of the ruling humanity's second to last hope to avoid extinction, she wastes away her day avoiding the paparazzi. Far more intelligent than her brother, the heir to for more than to be married off to the rulers of their enemy, the ice plane her family at the core and ruin any hope for peace between the two warring Helyn finds herself marooned and lost in the jungle, fighting for her life army of Avalonian agents hunting her down. Helyn isn't alone, protected by how to navigate the dangers of the wilderness. If Helyn hopes to survive an knows she was born to be, she needs to use every ounce of her strategic bri the entire life she has been given on a silver platter. Will she step up? O part of a science fiction trilogy that retells the story of Shakespeare's H of leaders are sometimes the ones we need most.
'''
```

Let us see how this new description scores:

```
In [146]: print_scores(arcadium_2, mode='genre')
```

Out[146]:

| Probabilities | |
|--------------------|----------|
| Fantasy | 0.788611 |
| Romance | 0.359704 |
| Speculative | 0.290490 |
| Adventure | 0.287620 |
| Dystopia | 0.280270 |
| Space Opera | 0.276021 |
| Aliens | 0.271481 |
| Space | 0.246738 |
| War | 0.223977 |
| Paranormal | 0.183141 |
| Horror | 0.179801 |
| Apocalyptic | 0.175281 |
| Historical | 0.128452 |
| Steampunk | 0.113921 |
| Mystery | 0.109415 |
| Queer | 0.057833 |
| Time Travel | 0.030977 |

```
In [147]: print_scores(arcadium_2, mode='age')
```

Out[147]:

| Probabilities | |
|--------------------|----------|
| Adult | 0.573850 |
| Young Adult | 0.352897 |
| Children | 0.073253 |

In [149]: `most_impactful_words(arcadium_2, 10)`

Out[149]:

| | Value |
|-----------------|----------|
| knows | 0.364095 |
| hope | 0.266276 |
| family | 0.231359 |
| planet | 0.227306 |
| life | 0.164655 |
| trilogy | 0.163214 |
| question | 0.160813 |
| peace | 0.159670 |
| born | 0.158875 |
| taken | 0.158718 |

Here we see that a few categories have actually increased that maybe I wanted to reduce. For example, Romance is much higher on the rankings and *Arcadium* is absolutely not a romance story. Also, the adult score has dropped too, so maybe I made this look a little more like a young adult novel. So, the rewrite wasn't necessarily the obvious direction that I wanted to take.

How to turn this into actionable insights? I will discuss that in the "Next Steps" section coming up.

Use Case 2 - Similar Books

The second use case is finding similar books and authors. With the `find_most_similar` function, we can restrict the books returned from the database to only books from the last 5-10 years. From there, an author can decide if the descriptions are thematically or tonally similar and then research those authors, their books, and, most crucially, their agents. This is all purely subjective in terms of how

Here is the new Arcadium's similarity information:

In [61]: `find_most_similar(arcadium_2, year=2010)`

Out[61]:

| | Book_Title | Author_Name | Year_published | Book_Description | Rating_votes | Review_number | F |
|------|-------------------|-----------------------|----------------|--|--------------|---------------|---|
| 597 | Provenance | Ann Leckie | 2017 | An ambitious young woman has just one chance t... | 14537 | 1741 | |
| 5389 | Archangel | William Gibson | 2017 | Science Fiction Superstar William Gibson's fir... | 1013 | 169 | |
| 414 | Born of Silence | Sherrilyn Kenyon | 2012 | \nDeath Stalks Them All...\nKere is the second... | 11105 | 762 | |
| 4929 | KOP Killer | Warren Hammond | 2012 | KOP Killer, a darkly dystopian science fiction... | 311 | 34 | |
| 4375 | Arclight | Josin L. McQuein | 2013 | No one crosses the wall of light . . . except ... | 4195 | 544 | |
| 685 | Cloak and Silence | Sherrilyn Kenyon | 2013 | Every Life Has A Price™One of the fiercest sol... | 6616 | 472 | |
| 8995 | The Terrans | Jean Johnson | 2015 | Jean Johnson's first novel in an explosive new... | 860 | 109 | |
| 7285 | Libre | S.H. Jucha | 2015 | The saga of the Rêveur continues in this secon... | 2388 | 130 | |
| 5878 | Shutdown | Heather Anastasiu | 2013 | The battle is all but over, and hope seems to ... | 1767 | 176 | |
| 7321 | Do Unto Others | Michael Z. Williamson | 2010 | Do Unto Others as They Did Unto You —the Code o... | 540 | 15 | |

```
In [161]: df = find_most_similar(arcadium_2, detail=1)
```

Most similar #2:

Title: Provenance Author: Ann Leckie Year: 2017

An ambitious young woman has just one chance to secure her future and reclaim her family's priceless lost artifacts in this stand-alone novel set in the world of Ann Leckie's groundbreaking, NYT bestselling Imperial Radch trilogy, which won the Hugo and Nebula awards. Nominated for the HUGO AWARD FOR BEST NOVEL 2018 Nominated for the LOCUS AWARD FOR BEST SCIENCE FICTION NOVEL 2018 Though she knows her brother holds her mother's favor, Ingrid is determined to at least be considered as heir to the family name. She hatches an audacious plan--free a thief from a prison planet from which no one has ever returned, and use them to help steal back a priceless artifact. But Ingray and her charge return to her home to find their planet in political turmoil, at the heart of an escalating interstellar conflict. Together, they must make a new plan to salvage Ingray's future and her world, before they are lost to her for good.

Curiously, though the genre scores changed fairly dramatically, the recommended similar books list is almost the same as the original Arcadium list. This means that, while the overall scores can change quite easily, the recommendations are a little more robust, which is really cool. Whether or not that's a good thing, I need to test further to see.

Further Exploration

As I mentioned in the beginning, this tool is powerful, but it could use more work. The core dataset is comprised only of Science Fiction books, but, with more data from other genres, we could build different models for each genre as well as expand our similarity database to further aid authors in exploring other agents.

Beyond that, this same methodology could be used to try to predict a novel's success based on its description, though that would require book sales data. This data definitely exists, but because it is so valuable to the publishing industry, it is supremely expensive.

Lastly, this data does not include one crucial column: Agents. If we enriched the data with the agents who represent the books, we can start to see patterns in agent tastes and preferences. Again, finding that data can be a challenge/expensive, but it would increase the value of this tool immeasurably.

I plan to continue working on this model by expanding the number of genres as well as the size of the overall dataset. If I can fold in direct agent information to create new insights, that would be the ultimate goal.

Novel Nexus Streamlit App

As for deployment I have a number of features and objectives I want to include for new authors. My app lives in this GitHub repo, so feel free to explore it. Here are the current goals for the app:

- Allow authors to upload and score a book description based on genre and age groups
- Print out 10 most similar books with the ability to drill into individual book descriptions
- Allow authors to upload a second book description (a different book or a second draft) and see the difference in genre and age scores
- Compare the vector values based on the words measured in each description to see which words contribute to the differences
- Be able to measure a book description's similarity to the average vector of the author's desired genres so they know which words to remove and which to add in to change scores
- See a highlighted presentation of the description with the measured/important words highlighted

I will continue to work on this app over time with more updates to make it as useful to non-technical authors as much as possible.

Resources

Writing Resources

- [How to Write a Query Letter](https://www.janefriedman.com/query-letters/) (<https://www.janefriedman.com/query-letters/>)
- [Determining Sci-Fi Sub-Genres](https://writersrelief.com/2011/07/11/determine-book-genre/) (<https://writersrelief.com/2011/07/11/determine-book-genre/>)
- [Writing a Science Fiction Cover Letter](https://writersrelief.com/2018/05/31/query-letter-genre-essentials-pitching-sci-fi-and-fantasy-novels-writers-relief/) (<https://writersrelief.com/2018/05/31/query-letter-genre-essentials-pitching-sci-fi-and-fantasy-novels-writers-relief/>)

NLP Resources

- [How Spacy Words](https://spacy.io/usage/spacy-101) (<https://spacy.io/usage/spacy-101>)
- [TF-IDF Vectorization - Towards Data Science Blog](https://towardsdatascience.com/text-vectorization-term-frequency-inverse-document-frequency-tfidf-5a3f9604da6d) (<https://towardsdatascience.com/text-vectorization-term-frequency-inverse-document-frequency-tfidf-5a3f9604da6d>)
- [Skip-Grams - Towards Data Science Blog](https://towardsdatascience.com/skip-gram-nlp-context-words-prediction-algorithm-5bbf34f84e0c) (<https://towardsdatascience.com/skip-gram-nlp-context-words-prediction-algorithm-5bbf34f84e0c>)
- [SpaCy Lemmatizer Documentation](https://spacy.io/api/lemmatizer) (<https://spacy.io/api/lemmatizer>)
- [Multi-Label Classification Metrics - Towards Data Science Blog](https://towardsdatascience.com/journey-to-the-center-of-multi-label-classification-384c40229bff) (<https://towardsdatascience.com/journey-to-the-center-of-multi-label-classification-384c40229bff>)