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Final Project: Covid 19 Bing Search Query Exploration

Github link: https://github.com/edwinvillafane/cisb63-final

This project is using Microsoft Bing search queries related to Covid19. This dataset was curated from the Bing search logs (desktop users only) over the period of Jan 1st, 2020 – (Current Month - 1). Dataset includes queries from all over the world that had an intent related to the Coronavirus or Covid-19. In some cases this intent is explicit in the query itself, e.g. “Coronavirus updates Seattle” in other cases it is implicit , e.g. “Shelter in place”. The data for this project is available to download on Kaggle at: https://www.kaggle.com/datasets/saurabhshahane/microsoft-bing-search-for-corona-virus-intent/

My overall goal for this project is to apply some advanced NLP techniques such as text summarization and word embedding cluster visualizations to better understand different ways that people were using Bing to learn about COVID 19 developments.

This project uses the following Python libraries and NLP techniques

- Numpy, Pandas, Matplotlib and seaborn
- NLTK, Word2Vec, Scikit-learn, LDA, Transformers, Wordcloud, spacy

Section 1: Exploratory Data Analysis

In [5]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

import nltk
from nltk.corpus import stopwords
from nltk.tokenize import sent_tokenize, word_tokenize
from sklearn.feature_extraction.text import TfidfVectorizer

import re
import warnings
warnings.filterwarnings('ignore')
```

In [9]:
```python
# only focus on Queries by Country for month of June
df = pd.read_csv('./data/QueriesByCountry_2020-06-01_2020-06-30.tsv', sep='\t')
df.head()
```

Out[9]:

	Date	Query	IsImplicitIntent	Country	PopularityScore
0	2020-06-01	covid antibody test near me	False	United States	1
1	2020-06-01	ouverture frontière belge	True	France	1
2	2020-06-01	connect myflorida login	True	United States	17
3	2020-06-01	covid antibody test	False	United States	1
4	2020-06-01	covid antibody	False	United States	1

Handling Missing or Null Values Data Transformation use: Describe, head, info, etc

In [11]:
```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 392193 entries, 0 to 392192
Data columns (total 5 columns):
 #   Column           Non-Null Count   Dtype 
---  ------           --------------   ----- 
 0   Date             392193 non-null  object
 1   Query            392193 non-null  object
 2   IsImplicitIntent 392193 non-null  bool  
 3   Country          392193 non-null  object
 4   PopularityScore  392193 non-null  int64 
dtypes: bool(1), int64(1), object(3)
memory usage: 12.3+ MB
```

In [12]:
```python
df.describe()
```

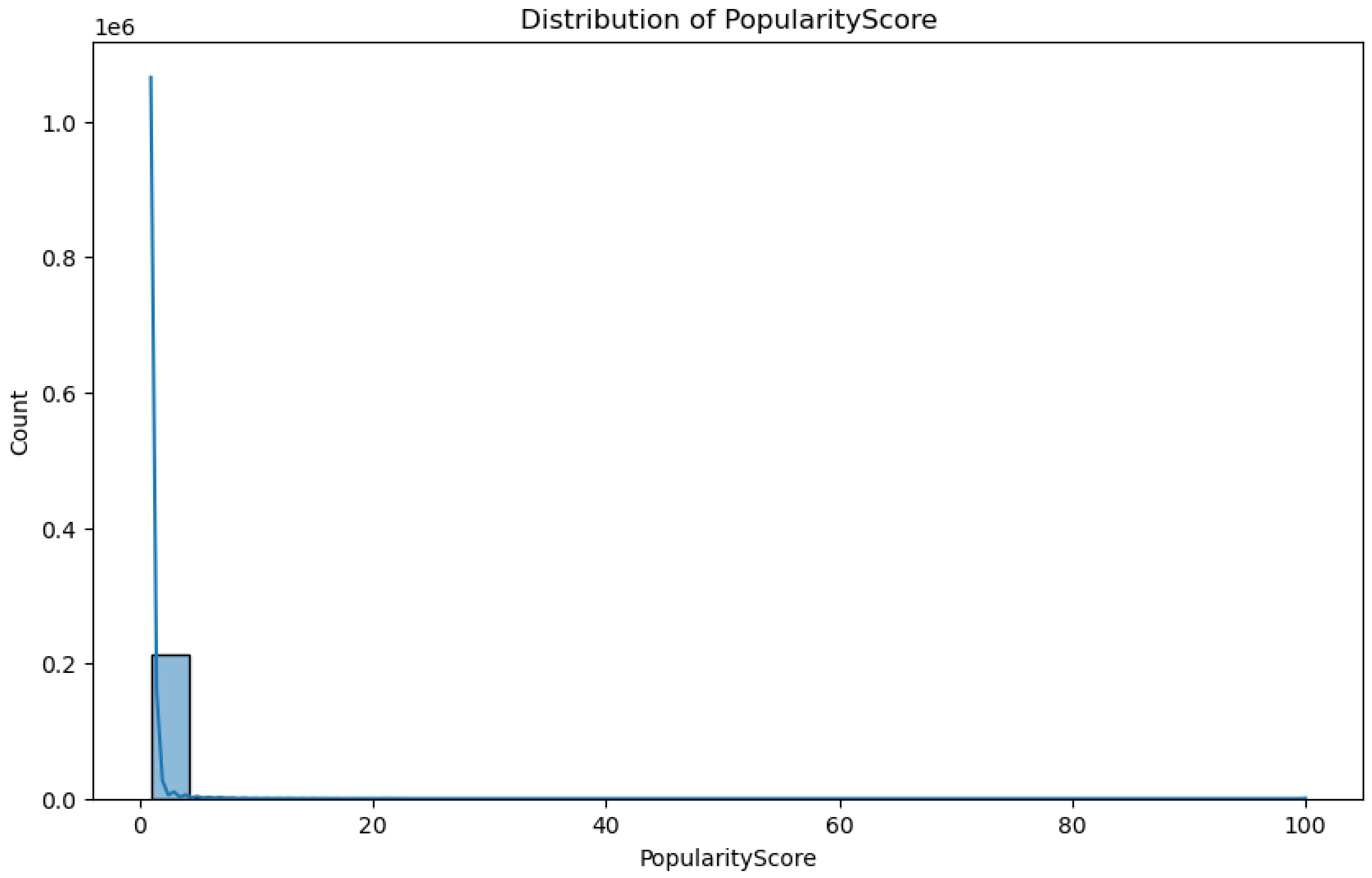
Out[12]:

	PopularityScore
count	392193.000000
mean	2.840874
std	10.053766
min	1.000000
25%	1.000000
50%	1.000000
75%	1.000000
max	100.000000

Given that this slice of data is happening relatively early on in the pandemic, it makes sense why many of the search queries have low PopularityScores as interest in these queries may not be really popular compared to March 2020 or later on when vaccines started rolling out.

In [112…

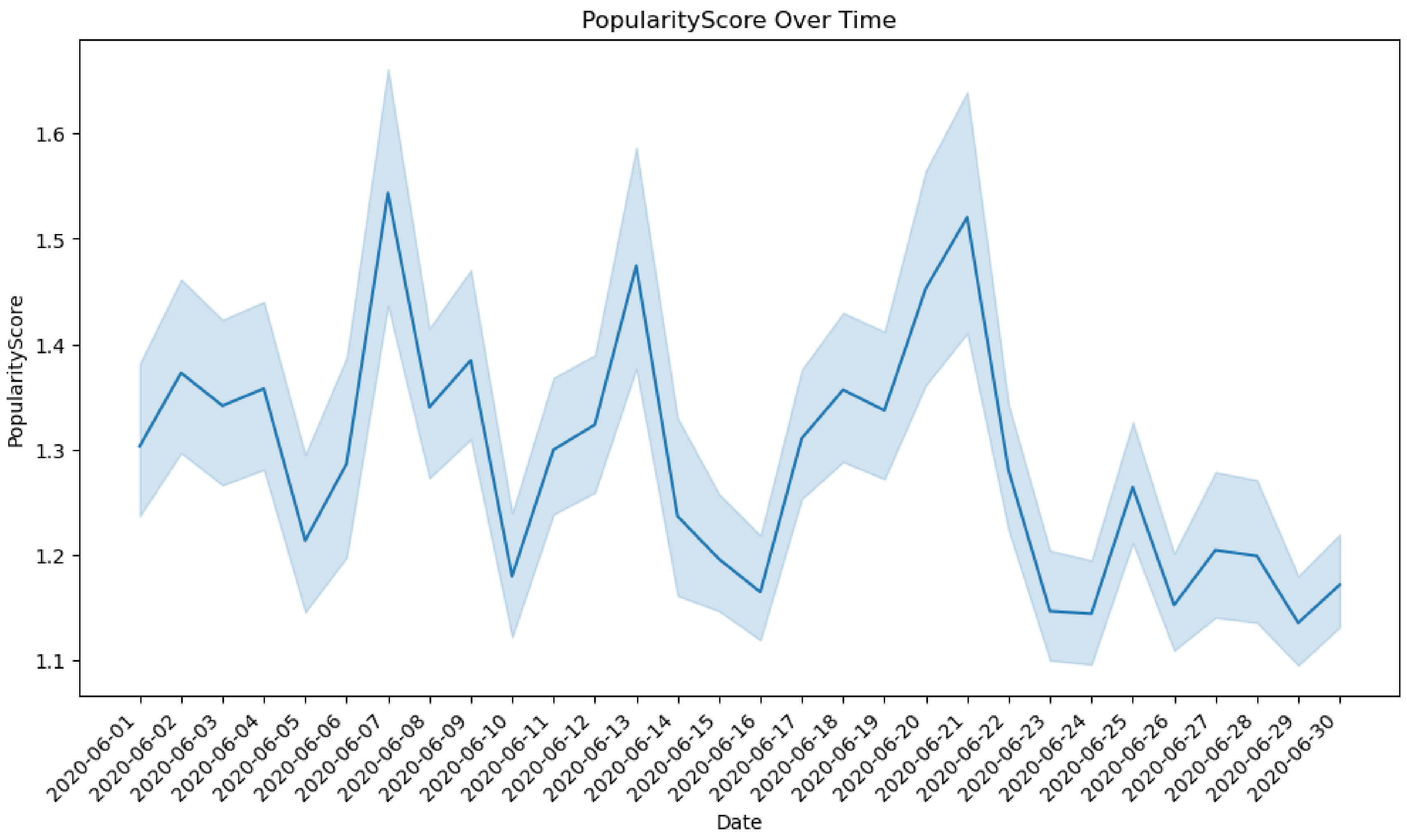
```
# Visualize the distribution of 'PopularityScore'
plt.figure(figsize=(10, 6))
sns.histplot(df['PopularityScore'], bins=30, kde=True)
plt.title('Distribution of PopularityScore')
plt.show()
```



Popularity score over the course of a month doesn't seem to show us anything particularly insightful, perhaps it would be more interesting to look at a sample of search queries over the 2 years.

In [116…

```
plt.figure(figsize=(12, 6))
sns.lineplot(x='Date', y='PopularityScore', data=df)
plt.title('PopularityScore Over Time')
plt.xticks(rotation=45, ha='right')
plt.show()
```



```
In [13]: df['Country'].unique()
```

```
Out[13]: array(['United States', 'France', 'United Kingdom', 'Canada', 'India',
        'Australia', 'China', 'Panama', 'Germany', 'Puerto Rico', 'Italy',
        'Korea (South)', 'Czech Republic', 'Argentina', 'South Africa',
        'Brazil', 'Nigeria', 'Mexico', "Cote D'ivoire", 'Guatemala',
        'Sweden', 'Zimbabwe', 'Taiwan', 'Serbia', 'Tunisia', 'Japan',
        'Austria', 'New Zealand', 'Hong Kong', 'Belgium', 'Qatar', 'Ghana',
        'Turkey', 'Saudi Arabia', 'Reunion', 'Mayotte', 'Aland Islands',
        'Trinidad And Tobago', 'Guyana', 'Isle Of Man', 'Colombia',
        'Cayman Islands', 'Georgia', 'Russian Federation', 'Lesotho',
        'Ukraine', 'Pakistan', 'Romania', 'Dominican Republic', 'Oman',
        'Singapore', 'Hungary', 'Chile', 'Morocco', 'Zambia', 'Honduras',
        'Martinique', 'Jersey', 'Thailand', 'Papua New Guinea', 'Spain',
        'Philippines', 'Indonesia', 'Barbados', 'Belize', 'Saint Lucia',
        'Uganda', 'Namibia', 'Guam', 'Angola', 'Cambodia', 'Norway',
        'Algeria', 'Greece', 'Bangladesh', 'Malawi', 'Guernsey', 'Bahrain',
        'Ireland', 'Haiti', 'Switzerland', 'Iran', 'Cuba', 'Venezuela',
        'Slovak Republic', 'Uruguay', 'Solomon Islands', 'Peru', 'Bolivia',
        'Myanmar', 'Croatia', 'Nepal', 'Other Country', 'Bahamas',
        'French Polynesia', 'El Salvador', 'Andorra', 'Poland', 'Paraguay',
        'United Arab Emirates', 'Egypt', 'Finland', 'Portugal', 'Cyprus',
        'Denmark', 'Mauritius', 'Ethiopia', 'Ecuador', 'Kenya', 'Malta',
        'New Caledonia', 'Guadeloupe', 'Virgin Islands (U.S.)', 'Viet Nam',
        'Malaysia', 'Suriname', 'Costa Rica', 'Israel', 'Luxembourg',
        'Fiji', 'Tanzania', 'Lebanon', 'French Guiana', 'Botswana',
        'Netherlands', 'Sri Lanka', 'Slovenia', 'Jamaica', 'Bulgaria',
        'Kuwait', 'Antigua And Barbuda', 'Mozambique', 'Senegal',
        'Maldives', 'Lithuania', 'Nicaragua', 'Brunei Darussalam',
        'Monaco', 'Mongolia', 'Aruba', 'Madagascar', 'American Samoa',
        'San Marino', 'Kazakhstan', 'Azerbaijan', 'Gibraltar', 'Gabon',
        'Jordan', 'Iraq', 'Afghanistan', 'Rwanda', 'South Sudan',
        'Turks And Caicos Islands', 'Liberia', 'Swaziland', 'Uzbekistan',
        'Macedonia', 'Grenada', 'Estonia', 'Iceland'], dtype=object)
```

For the rest of the analysis, I will only be looking at data for the US, Italy, China and Nicaragua to reduce the amount of data processed and to get activity from all over the world.

```
In [41]: # let's only keep US, Italy, China, and Nicaragua
         selected_countries = ['United States', 'Italy', 'China', 'Nicaragua']

         filtered_df = df[df['Country'].isin(selected_countries)]
```

```
In [42]: filtered_df.head(20)
```

Out[42]:

	Date	Query	IsImplicitIntent	Country	PopularityScore
0	2020-06-01	covid antibody test near me	False	United States	1
2	2020-06-01	connect myflorida login	True	United States	17
3	2020-06-01	covid antibody test	False	United States	1
4	2020-06-01	covid antibody	False	United States	1
6	2020-06-01	connecticut coronavirus	False	United States	1
10	2020-06-01	connecticut coronavirus cases	False	United States	1
11	2020-06-01	covid antibodies test	False	United States	1
13	2020-06-01	connecticut coronavirus update	False	United States	1
14	2020-06-01	covid antibodies	False	United States	1
15	2020-06-01	connecticut covid	False	United States	1
17	2020-06-01	covid and riots	False	United States	1
18	2020-06-01	connecticut news	True	United States	1
19	2020-06-01	covid and protests	False	United States	1
20	2020-06-01	conora virus	False	United States	1
21	2020-06-01	coronavirus statistics in united states	False	China	4
23	2020-06-01	covid and diabetes	False	United States	1
24	2020-06-01	conova virus update	False	United States	1
28	2020-06-01	covid alaska	False	United States	1
29	2020-06-01	conovirus update	False	United States	1
30	2020-06-01	covid alabama	False	United States	1

NLP Topic 1: Tokenization

In [43]:

```python
from tqdm import tqdm
import spacy

nlp = spacy.load("en_core_web_sm")

# Define a function to tokenize a single query
```

```
def tokenize_query(query):
    return [token.text.lower() for token in nlp(query)]

# Use tqdm on the apply operation
tqdm.pandas(desc="Tokenizing queries")
filtered_df['Tokens'] = filtered_df['Query'].progress_apply(tokenize_query)
```

```
Tokenizing queries: 100%|██████████| 216236/216236 [21:26<00:00, 168.14it/s]
```

NLP Topic 2 and 3: NER and Wordcloud

In [118…

```
sample_query = "coronavirus statistics in united states "
doc = nlp(sample_query)

print("Named Entities:")
for ent in doc.ents:
    print(f"{ent.text}: {ent.label_}")
```

```
Named Entities:
united states: GPE
```

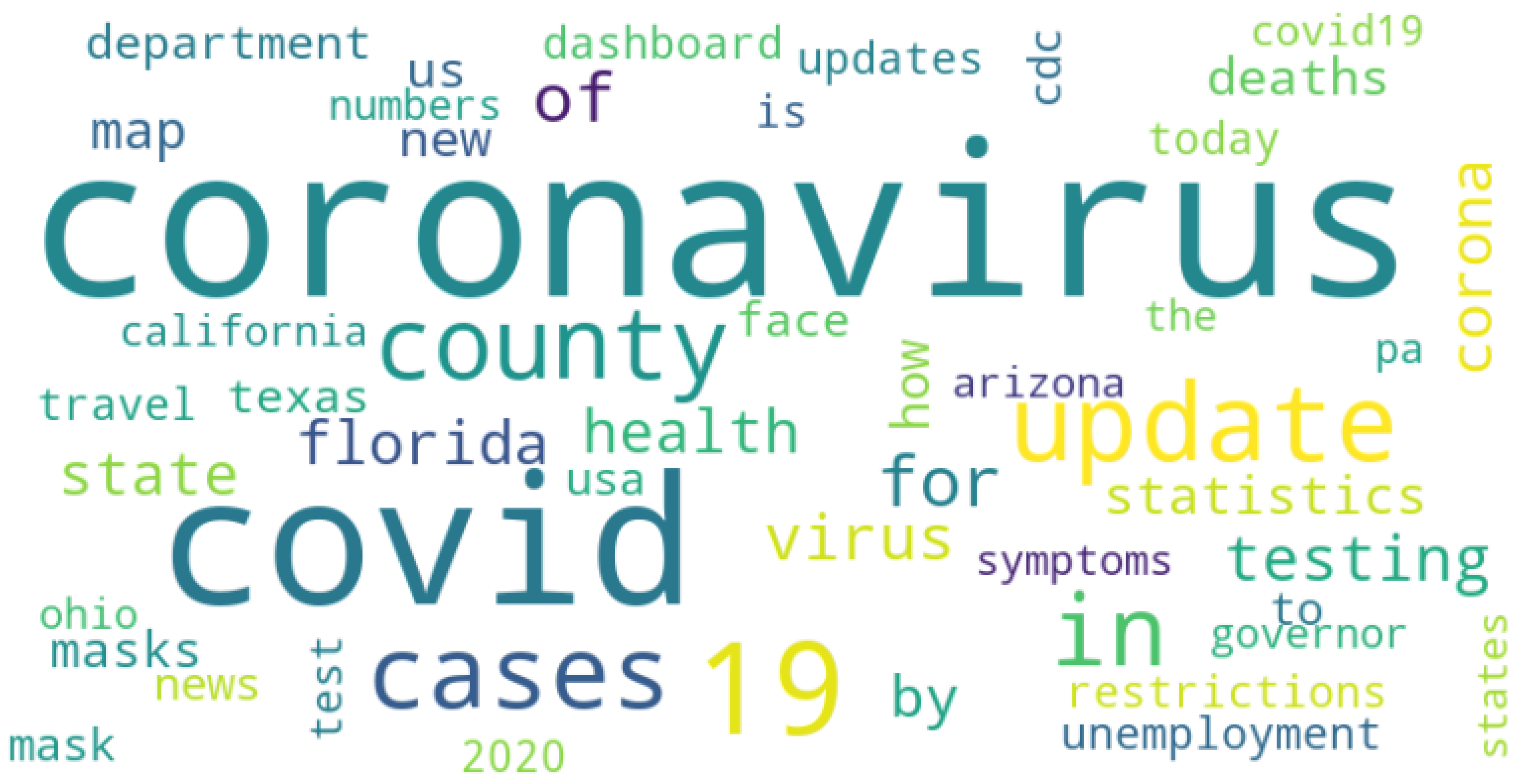
In [109…

```
from collections import Counter

all_tokens = [token for sublist in filtered_df['Tokens'] for token in sublist]

token_counts = Counter(all_tokens)
sorted_tokens = sorted(token_counts.items(), key=lambda x: x[1], reverse=True)

# Select top entities
top_entities = dict(sorted(token_counts.items(), key=lambda x: x[1], reverse=True)[:50])
```

The top keywords make sense given the nature of the dataset. Obviously coronavirus, covid19 are top words and since the dataset includes the US many of the US states are included in here. "Symptoms" and "update" also make sense because people would be searching for more information related to these two.

In [110…

```
from wordcloud import WordCloud

wordcloud = WordCloud(width=800, height=400, background_color='white').generate_from_frequencies(top_entities

plt.figure(figsize=(10, 5))
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
plt.show()
```

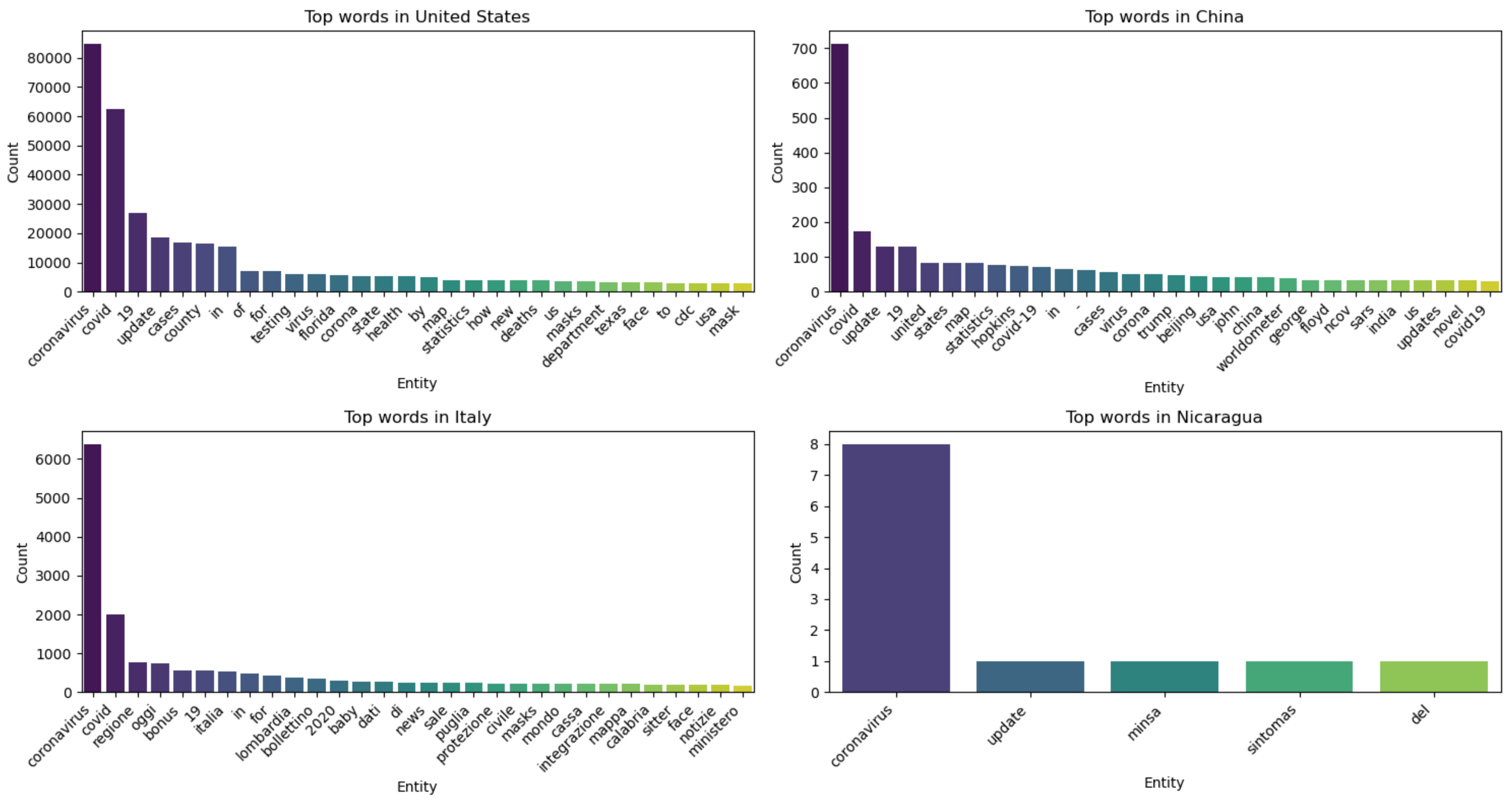


The top words across the 4 different countries also makes sense as words for China, Italy and Nicaragua include words that are in different languages and local to that specifici country, such as "Wuhan" and "sintomas."

In [119…

```
import seaborn as sns
all_tokens = [token for sublist in filtered_df['Tokens'] for token in sublist]
token_counts = Counter(all_tokens)
sorted_tokens = sorted(token_counts.items(), key=lambda x: x[1], reverse=True)

def get_top_entities(country_df):
    all_tokens = [token for sublist in country_df['Tokens'] for token in sublist]
    token_counts = Counter(all_tokens)
    sorted_tokens = sorted(token_counts.items(), key=lambda x: x[1], reverse=True)
    top_entities = sorted_tokens[:30]
    return pd.DataFrame(top_entities, columns=['Entity', 'Count'])

countries = filtered_df['Country'].unique()

plt.figure(figsize=(15, 8))
```

```python
for i, country in enumerate(countries, 1):
    plt.subplot(2, 2, i)  # Adjust the subplot grid based on the number of unique countries
    subset = filtered_df[filtered_df['Country'] == country]
    top_entities_subset = get_top_entities(subset)
    sns.barplot(x='Entity', y='Count', data=top_entities_subset, palette='viridis')
    plt.title(f'Top words in {country}')
    plt.xlabel('Entity')
    plt.ylabel('Count')
    plt.xticks(rotation=45, ha='right')

plt.tight_layout()
plt.show()
```



NLP Application 1: Sentiment Analysis

```
In [24]: import nltk
         from nltk.sentiment import SentimentIntensityAnalyzer
         nltk.download('vader_lexicon')

         [nltk_data] Downloading package vader_lexicon to
         [nltk_data]     /Users/edwinv/nltk_data...
Out[24]: True
```

```
In [56]: # Load NLTK SentimentIntensityAnalyzer
         sid = SentimentIntensityAnalyzer()

         # Function to get sentiment scores for a query
         def get_sentiment_scores(query):
             return sid.polarity_scores(query)

         tqdm.pandas(desc="sentiment scores per query")
         filtered_df['SentimentScores'] = filtered_df['Query'].progress_apply(get_sentiment_scores)

         # Extract sentiment scores into separate columns
         filtered_df[['Negative', 'Neutral', 'Positive', 'Compound']] = pd.DataFrame(filtered_df['SentimentScores'].to

         sentiment scores per query: 100%|██████| 216236/216236 [00:29<00:00, 7348.66it/s]
```

```
In [67]: filtered_df.head(40)
```

Out[67]:

	Date	Query	IsImplicitIntent	Country	PopularityScore	Tokens	SentimentScores	Negative	Neutral	Positive	Compo
0	2020-06-01	covid antibody test near me	False	United States	1	[covid, antibody, test, near, me]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
2	2020-06-01	connect myflorida login	True	United States	17	[connect, myflorida, login]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
3	2020-06-01	covid antibody test	False	United States	1	[covid, antibody, test]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
4	2020-06-01	covid antibody	False	United States	1	[covid, antibody]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
6	2020-06-01	connecticut coronavirus	False	United States	1	[connecticut, coronavirus]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
10	2020-06-01	connecticut coronavirus cases	False	United States	1	[connecticut, coronavirus, cases]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
11	2020-06-01	covid antibodies test	False	United States	1	[covid, antibodies, test]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
13	2020-06-01	connecticut coronavirus update	False	United States	1	[connecticut, coronavirus, update]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
14	2020-06-01	covid antibodies	False	United States	1	[covid, antibodies]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
15	2020-06-01	connecticut covid	False	United States	1	[connecticut, covid]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
17	2020-06-01	covid and riots	False	United States	1	[covid, and, riots]	{'neg': 0.623, 'neu': 0.377, 'pos': 0.0, 'comp...	0.623	0.377	0.000	-0.5
18	2020-06-01	connecticut news	True	United States	1	[connecticut, news]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0

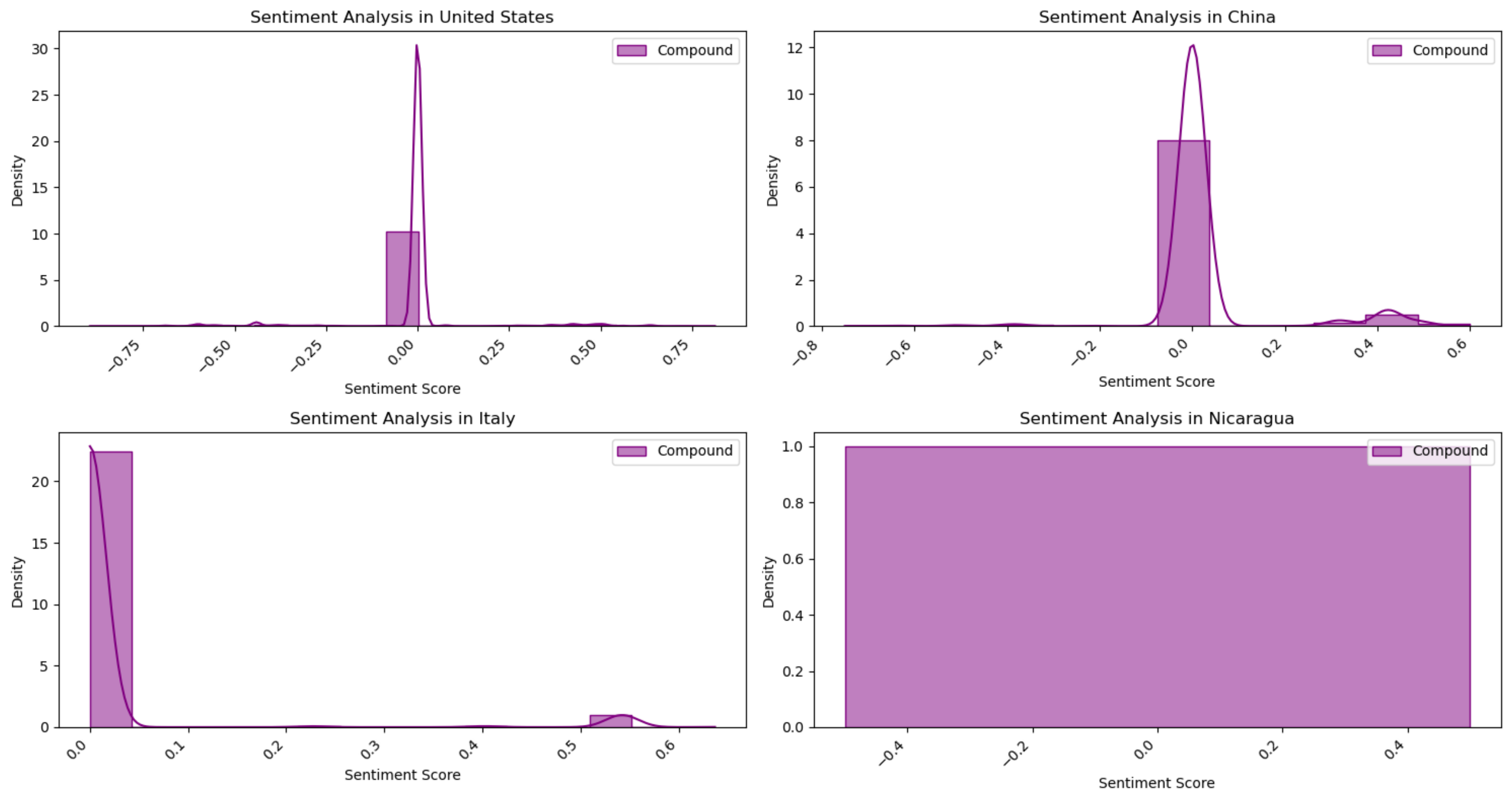
	Date	Query	IsImplicitIntent	Country	PopularityScore	Tokens	SentimentScores	Negative	Neutral	Positive	Compo
19	2020-06-01	covid and protests	False	United States	1	[covid, and, protests]	{'neg': 0.487, 'neu': 0.513, 'pos': 0.0, 'comp...	0.487	0.513	0.000	-0.2
20	2020-06-01	conora virus	False	United States	1	[conora, virus]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
21	2020-06-01	coronavirus statistics in united states	False	China	4	[coronavirus, statistics, in, united, states]	{'neg': 0.0, 'neu': 0.588, 'pos': 0.412, 'comp...	0.000	0.588	0.412	0.4
23	2020-06-01	covid and diabetes	False	United States	1	[covid, and, diabetes]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
24	2020-06-01	conova virus update	False	United States	1	[conova, virus, update]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
28	2020-06-01	covid alaska	False	United States	1	[covid, alaska]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
29	2020-06-01	conovirus update	False	United States	1	[conovirus, update]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
30	2020-06-01	covid alabama	False	United States	1	[covid, alabama]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
32	2020-06-01	conspiracy theories covid 19	False	United States	1	[conspiracy, theories, covid, 19]	{'neg': 0.531, 'neu': 0.469, 'pos': 0.0, 'comp...	0.531	0.469	0.000	-0.5
34	2020-06-01	covid act now	False	United States	1	[covid, act, now]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
36	2020-06-01	contact tracer	True	United States	1	[contact, tracer]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
41	2020-06-01	contact tracers	True	United States	1	[contact, tracers]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0

	Date	Query	IsImplicitIntent	Country	PopularityScore	Tokens	SentimentScores	Negative	Neutral	Positive	Compo
42	2020-06-01	covid acronym	False	United States	1	[covid, acronym]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
43	2020-06-01	contact tracing	True	United States	1	[contact, tracing]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
44	2020-06-01	covid 401k rules	False	United States	1	[covid, 401k, rules]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
45	2020-06-01	contact tracing covid	False	United States	1	[contact, tracing, covid]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
46	2020-06-01	covid 20	False	United States	1	[covid, 20]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
48	2020-06-01	coronavirus uk	False	China	5	[coronavirus, uk]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
49	2020-06-01	contact tracing jobs	True	United States	1	[contact, tracing, jobs]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
51	2020-06-01	covid 19.ca.gov	False	United States	1	[covid, 19.ca.gov]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
53	2020-06-01	contact tracing training	True	United States	1	[contact, tracing, training]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
55	2020-06-01	covid 19, california	False	United States	1	[covid, 19, ,, california]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
56	2020-06-01	contagion movie	True	United States	1	[contagion, movie]	{'neg': 0.75, 'neu': 0.25, 'pos': 0.0, 'compou...	0.750	0.250	0.000	-0.4
57	2020-06-01	covid 19 wv	False	United States	1	[covid, 19, wv]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0

	Date	Query	IsImplicitIntent	Country	PopularityScore	Tokens	SentimentScores	Negative	Neutral	Positive	Compo
60	2020-06-01	contra costa county corona virus update	False	United States	1	[contra, costa, county, corona, virus, update]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
61	2020-06-01	covid 19 written report cde	False	United States	1	[covid, 19, written, report, cde]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
63	2020-06-01	contra costa county coronavirus	False	United States	1	[contra, costa, county, coronavirus]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0
64	2020-06-01	covid 19 worldwide tracking	False	United States	1	[covid, 19, worldwide, tracking]	{'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound...	0.000	1.000	0.000	0.0

Looking at the compound sentiment across countries also tend to trend negative or very low positive scores. This makes sense as the searches included words such as "deaths", "virus" and "symptoms" which can have lower scores. Since many of these searches are scientific and emotionless in nature, the overall sentiment should be close to zero rather than positive.

```
In [66]: countries = df['Country'].unique()
         colors = {'Negative': 'red', 'Neutral': 'blue', 'Positive': 'green', 'Compound': 'purple'}

         plt.figure(figsize=(15, 8))

         for i, country in enumerate(countries, 1):
             plt.subplot(2, 2, i)  # Adjust the subplot grid based on the number of unique countries
             subset = filtered_df[filtered_df['Country'] == country]
             for sentiment_category in ['Compound']:
                 sns.histplot(subset[sentiment_category], label=sentiment_category, kde=True, element="step", stat="de
             plt.title(f'Sentiment Analysis in {country}')
             plt.xlabel('Sentiment Score')
             plt.legend()
             plt.xticks(rotation=45, ha='right')

         plt.tight_layout()
         plt.show()
```



NLP topic 4: Parts of Speech tagging

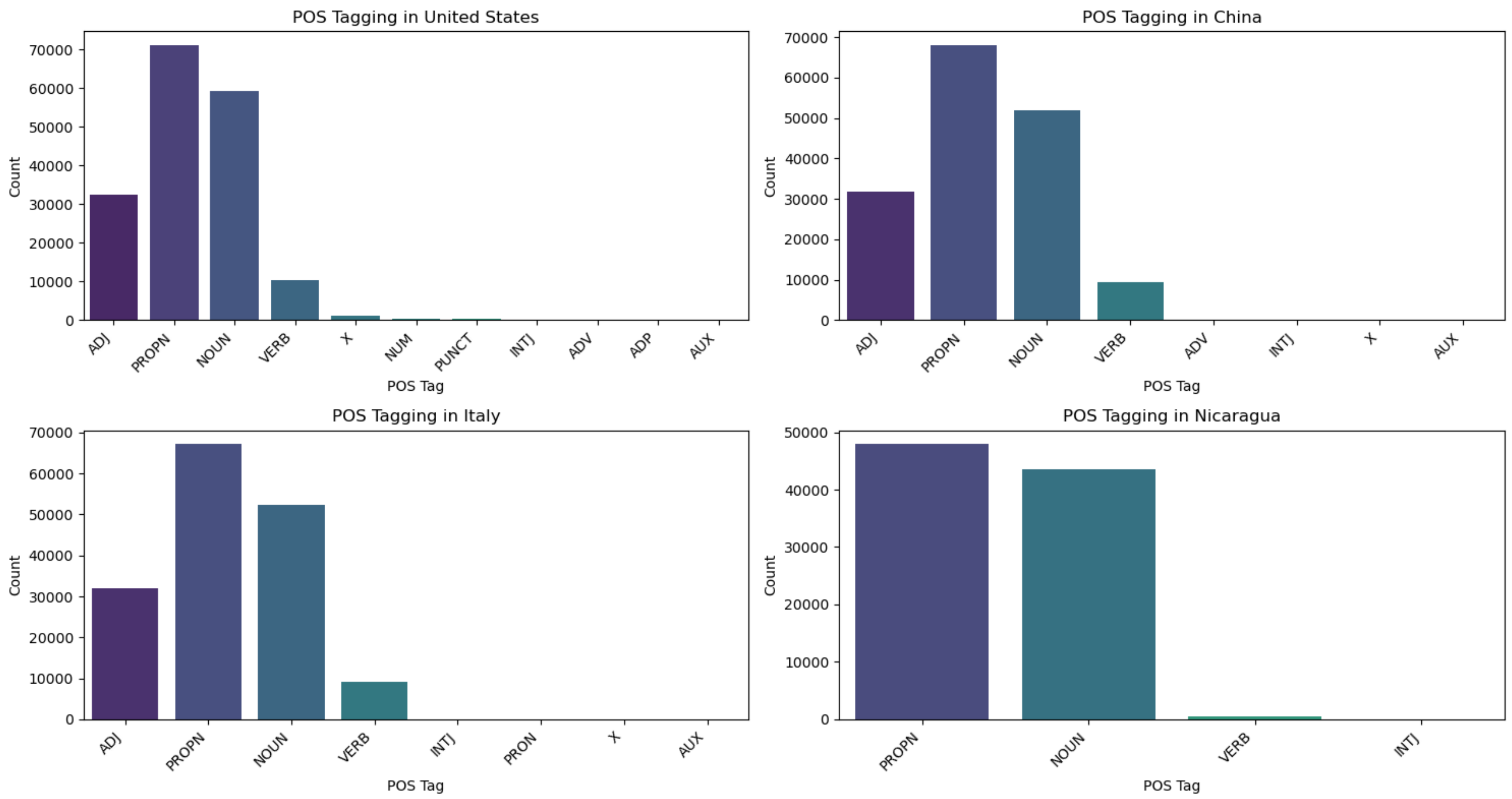
```
In [68]: def get_pos_tags(query):
             doc = nlp(query)
             return [(token.text, token.pos_) for token in doc]

         tqdm.pandas(desc="POS tags for each query")
         filtered_df['POSTags'] = filtered_df['Query'].progress_apply(get_pos_tags)
```

```
POS tags for each query: 100%|██████████| 216236/216236 [39:14<00:00, 91.84it/s]
```

```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
~/opt/anaconda3/lib/python3.9/site-packages/pandas/core/indexes/base.py in get_loc(self, key, method, toleran
ce)
   3628             try:
-> 3629                 return self._engine.get_loc(casted_key)
   3630             except KeyError as err:

~/opt/anaconda3/lib/python3.9/site-packages/pandas/_libs/index.pyx in pandas._libs.index.IndexEngine.get_loc
()

~/opt/anaconda3/lib/python3.9/site-packages/pandas/_libs/index.pyx in pandas._libs.index.IndexEngine.get_loc
()

pandas/_libs/hashtable_class_helper.pxi in pandas._libs.hashtable.PyObjectHashTable.get_item()

pandas/_libs/hashtable_class_helper.pxi in pandas._libs.hashtable.PyObjectHashTable.get_item()

KeyError: 'POSTags'

The above exception was the direct cause of the following exception:

KeyError                                  Traceback (most recent call last)
/var/folders/m2/sl6n6_9n0jvgly7113dtr0xm0000gp/T/ipykernel_80327/3486395755.py in <module>
      6 filtered_df['POSTags'] = filtered_df['Query'].progress_apply(get_pos_tags)
      7 
----> 8 pos_tags_df = pd.DataFrame([(token, pos) for query_pos_tags in df['POSTags'] for token, pos in query_
pos_tags], columns=['Token', 'POS'])
      9 
     10 countries = filtered_df['Country'].unique()

~/opt/anaconda3/lib/python3.9/site-packages/pandas/core/frame.py in __getitem__(self, key)
   3503             if self.columns.nlevels > 1:
   3504                 return self._getitem_multilevel(key)
-> 3505             indexer = self.columns.get_loc(key)
   3506             if is_integer(indexer):
   3507                 indexer = [indexer]

~/opt/anaconda3/lib/python3.9/site-packages/pandas/core/indexes/base.py in get_loc(self, key, method, toleran
ce)
   3629                 return self._engine.get_loc(casted_key)
   3630             except KeyError as err:
-> 3631                 raise KeyError(key) from err
   3632             except TypeError:
   3633                 # If we have a listlike key, _check_indexing_error will raise
```

```
KeyError: 'POSTags'
```

```
In [69]: pos_tags_df = pd.DataFrame([(token, pos) for query_pos_tags in filtered_df['POSTags'] for token, pos in query_

         countries = filtered_df['Country'].unique()

         plt.figure(figsize=(15, 8))

         for i, country in enumerate(countries, 1):
             plt.subplot(2, 2, i)  # Adjust the subplot grid based on the number of unique countries
             subset = filtered_df[filtered_df['Country'] == country]
             sns.countplot(x='POS', data=pos_tags_df[pos_tags_df['Token'].isin(subset['Query'].explode().unique())], pa
             plt.title(f'POS Tagging in {country}')
             plt.xlabel('POS Tag')
             plt.ylabel('Count')
             plt.xticks(rotation=45, ha='right')

         plt.tight_layout()
         plt.show()
```



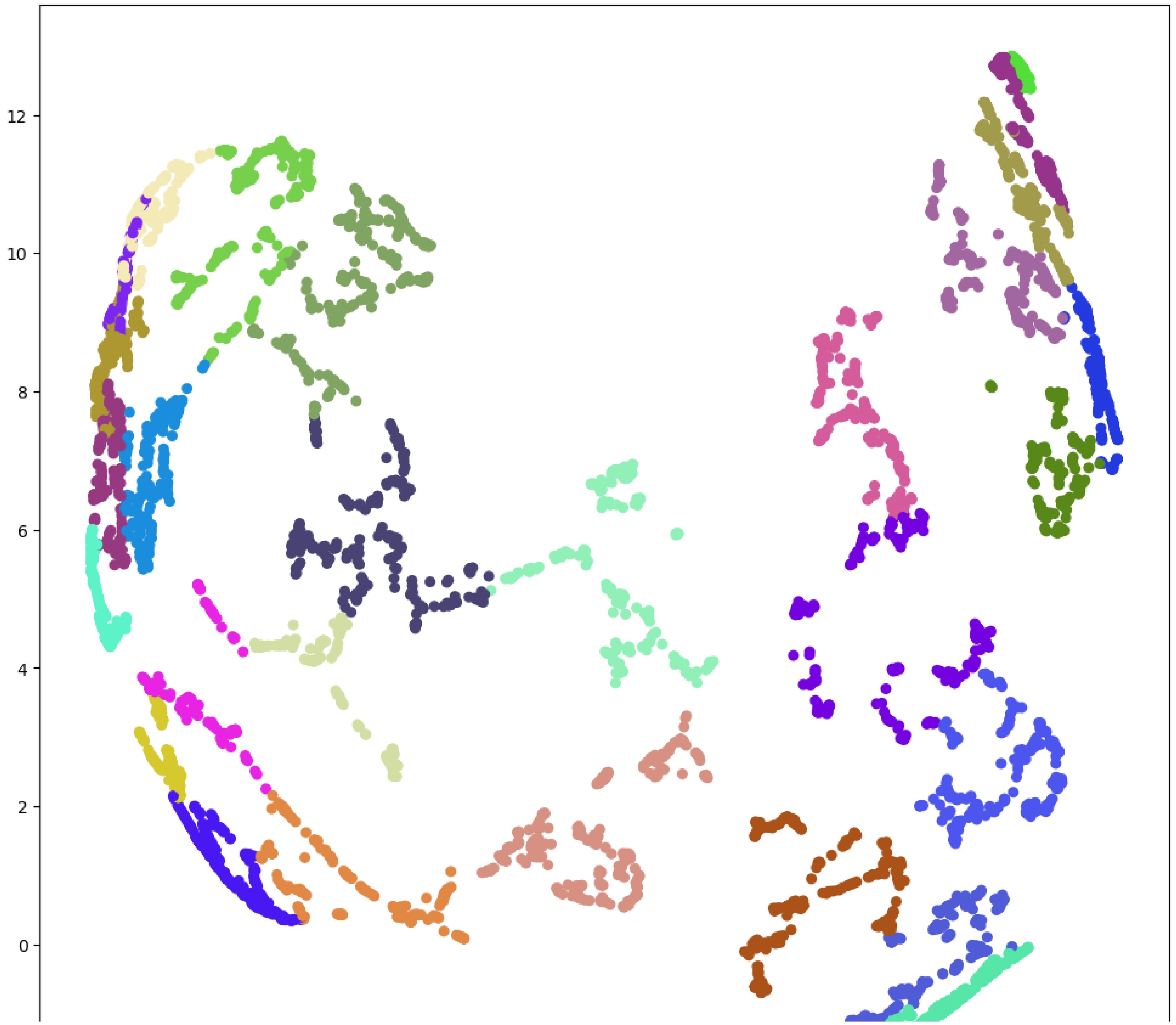
NLP topic 5: word2vec

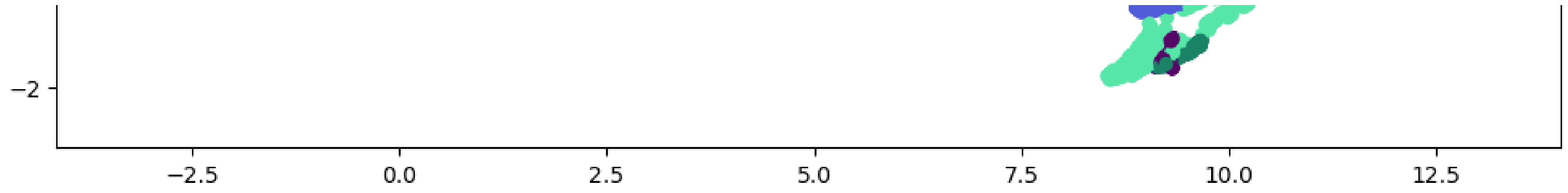
```
In [84]: from gensim.models import Word2Vec
         from nltk.tokenize import word_tokenize

         # Tokenize the queries
         tokenized_queries = filtered_df['Query'].apply(word_tokenize)

         # Train Word2Vec model
         word2vec_model = Word2Vec(tokenized_queries, vector_size=2, window=5, min_count=1, workers=4)

         # Example: Get the vector for a specific word (e.g., 'Coronavirus')
         vector = word2vec_model.wv['protest']
         print("Word2Vec Vector for 'protest':", vector)
```

```
word2vec_model.build_vocab(tokenized_queries)
word2vec_model.train(tokenized_queries, total_examples=word2vec_model.corpus_count, epochs=5)
```

```
Word2Vec Vector for 'protest': [-0.24823007  0.25900862]
Out[84]: (2235233, 3558720)
```

In [90]:
```
import umap
from sklearn.cluster import KMeans

X = word2vec_model.wv[word2vec_model.wv.key_to_index]

umap_model = umap.UMAP(n_neighbors=10, min_dist=0, n_components=3, random_state=42)
umap_result = umap_model.fit_transform(X)

kmeans = KMeans(n_clusters=30, random_state=42)
kmeans.fit(umap_result)
labels = kmeans.labels_

plt.figure(figsize=(12, 12))

colors = np.random.rand(len(set(labels)), 3)

plt.scatter(umap_result[:, 0], umap_result[:, 1], c=colors[labels], s=30)

plt.show()
```


12
10
8
6
4
2
0



NLP Application 2: Transformers and Text Summarization To better understand what each cluster is about, we can use text summarization.

In [95]:
```
# !pip install transformers
```

In [102…
```
from transformers import pipeline

summarizer = pipeline("summarization")

cluster_summaries = []
for cluster_label in set(labels):
    print('-------')
    print(cluster_label)
    cluster_data_indices = np.where(labels == cluster_label)[0]
    cluster_text = " ".join(filtered_df.iloc[cluster_data_indices]['Query'])

    summary = summarizer(cluster_text, max_length=50, min_length=5, length_penalty=2.0, num_beams=4, early_sto
    cluster_summaries.append(summary[0]['summary_text'])

for i, summary in enumerate(cluster_summaries):
    print(f"Cluster {i + 1} Summary: {summary}")
```

```
No model was supplied, defaulted to t5-small and revision d769bba (https://huggingface.co/t5-small).
Using a pipeline without specifying a model name and revision in production is not recommended.
All PyTorch model weights were used when initializing TFT5ForConditionalGeneration.

All the weights of TFT5ForConditionalGeneration were initialized from the PyTorch model.
If your task is similar to the task the model of the checkpoint was trained on, you can already use TFT5ForCo
nditionalGeneration for predictions without further training.
Token indices sequence length is longer than the specified maximum sequence length for this model (2261 > 51
2). Running this sequence through the model will result in indexing errors
```

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0
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1
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21
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```

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22
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23
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24
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25
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26
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27
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28
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29
Cluster 1 Summary: coronavirus statistics in mexico il resto del carlino reggio emilia worst states for coron
. tennessee pledge tauck sylvia browne s
Cluster 2 Summary: coronavirus update nebraska nh coron a virus update az coronanavirus sd covid 19 updates w
uhan china world o meters coronivirus statistics in
Cluster 3 Summary: coronavirus iowa governor inslee press conference indiana covid update icd 10 for covid ex
posure . michigan lockdown cvs michigan . update mich.gov coron
Cluster 4 Summary: coronavirus update nj covid 19 nevada covid . n95 covid 20 masks for kids . covid 19, ky c
ovid, 19 johns hopkins tracker coron
Cluster 5 Summary: covid 19 update coronavirus california fad trump twitter . tucker carlson covid 19, montan
a covid, 19 mn update . coron
Cluster 6 Summary: coronavirus san bernardino county sd dept of health sc covid 19 cases sba coronanavirus lo
ans . remdesivir coron
Cluster 7 Summary: covid 19 johns hopkins map covid . 19 deaths in us so far covid 19, utah coronavirus updat
e usa . tx rmd 2020 rite aid coron
Cluster 8 Summary: coronavirus uk covid 19 update nh covid . 19 posters cdc covid 18 pandemic hair treatment
consent form . covid in texas .
Cluster 9 Summary: coronavirus delaware update covid 19 cases in new york state today . covid 19, illinois, t
exas, tennessee, utah, kentuck
Cluster 10 Summary: coronavirus reopening ri pierce county wi phoebe putney memorial hospital phase 4 stimulu
s vote . nc dhhs navajo nation news n95 masks
Cluster 11 Summary: coronavirus over volotea sito ufficiale www.worldometers.info/coronanavirus www.johnhopki
n.edu coron a virus www.cdc.
Cluster 12 Summary: wisconsin coronavirus cases trump press conference today scadenza imu 2020 . coronanaviru
s tom wolf . timeline of coron avirus statistics . on coronona
Cluster 13 Summary: coronavirus is a virus in canada . ohio gov coronanavirus in wisconsin incubation period
. coroninavirus ny oggi in penn
Cluster 14 Summary: covid antibodies test connecticut coronavirus cases covid covid . covid and diabetes cono
va virus update covid alaska .
Cluster 15 Summary: coronavirus bonus baby sitter 2020 va covid 19 update us canada border reopening travel t
o france . covid19greenbergwired self quarantine sedgwick walmart sd covid cases poke
```

```
Cluster 16 Summary: coronavirus updates alabama coron avirus update in kansas . coronanavirus statistics in n
orth dakota svezia vacanze estate in italia coron
Cluster 17 Summary: coronavirus state of illinois covid 19 cases bollettino covid 1 giugno texas covid 18 cas
es nj covid19 update nh . covid
Cluster 18 Summary: coronavirus nel mondo yuma county coronanavirus www.coronavir.maryland.gov wisconsin smal
l business grants wilco covid 19 what is cor
Cluster 19 Summary: covid 19 xi jinping wyoming wwii wjiiioiiui n95 coronavirus deaths nj covid 19, iow
Cluster 20 Summary: covid 19 update illinois corona virus in texas . utah covid 19, symptons, nyc, new york,
arizona, i
Cluster 21 Summary: coronavirus st charles county coronanavirus update senate vote today schools covid 19 san
ta clara county covid san antonio covid rodney how
Cluster 22 Summary: coronavirus in kansas confirms coron a virus update utah coronanavirus update san diego c
oronnavirus updates bing coroninavirus trends
Cluster 23 Summary: covid 19 update kentucky corona virus dashboard nc covid19 update new york covid-19 updat
e texas covid 18 update ny covid . nebraska coron
Cluster 24 Summary: coronavirus in francia inarcassa burioni . sturgis 2020 states with travel restrictions .
coronanavirus santa clara covid 19 virginia co
Cluster 25 Summary: connecticut coronavirus update covid act now contact tracing jobs covid 19.ca.gov contra
costa covid 19 wisconsin cases covid 18 weakening cornavirus covid . washington
Cluster 26 Summary: covid 19 worldwide tracking convalescent plasma covid nc corona virus nh covid 20 tracker
bing la county . covid 18 nr corononavirus cases in alab
Cluster 27 Summary: coronavirus toscana ultime notizie wv dhhr covid 19 the stand stephen king symptoms in ch
ildren sumner county tn state of hawaii . coron
Cluster 28 Summary: coronavirus update ct coronanavirus sc coroninavirus cassa integrazione in deroga 2020 ca
rtelli covid per esercenti wyoming
Cluster 29 Summary: covid 401k rules covid 19, california contra costa county coronavirus update . wikipedia
covid 19 wiki coron a virus update knox county health department how long does cor
Cluster 30 Summary: covid 19 map what is open in michigan due to covid 18 testnebraska.com for covid state fa
rm insurance refund check snohomish county phase 2 signs and symptoms of coronavirus peach
```

Cluster 15 is interesting because it appears to be about stimulus checks, border reopenings, and travel. Cluster 25 appears to be related to new jobs that resulted from the pandemic.

Overall, the summarization is not that good... removal of stopwords and specific words related to this dataset such as "covid" would make the results better.

Let's see if we can understand the dataset using LDA, another way of extracting the general topics in a large corpus of text.

NLP topics 6 and 7: LDA and BOW

In [117…
```python
from gensim import corpora
from gensim.models import LdaModel
from nltk.tokenize import word_tokenize
```

```python
# Create a dictionary and corpus
dictionary = corpora.Dictionary(tokenized_queries)
corpus = [dictionary.doc2bow(query) for query in tokenized_queries]

# Train LDA model
lda_model = LdaModel(corpus, num_topics=30, id2word=dictionary, passes=10)

# Display topics
print("LDA Topics:")
for topic in lda_model.print_topics():
    print(topic)
```

```
LDA Topics:
(12, '0.287*"restrictions" + 0.239*"travel" + 0.112*"coronavirus" + 0.108*"covid" + 0.070*"alabama" + 0.056
*"free" + 0.039*"hawaii" + 0.027*"cornavirus" + 0.006*"costa" + 0.006*"lazio"')
(1, '0.274*"news" + 0.146*"coronavirus" + 0.119*"covid" + 0.101*"rate" + 0.069*"missouri" + 0.063*"la" + 0.03
3*"italy" + 0.032*"vermont" + 0.019*"chicago" + 0.017*"latest"')
(10, '0.307*"testing" + 0.281*"covid" + 0.111*"test" + 0.051*"coronavirus" + 0.029*"sites" + 0.029*"oklahoma"
+ 0.027*"tennessee" + 0.025*"antibody" + 0.023*"blood" + 0.022*"signs"')
(3, '0.179*"california" + 0.172*"coronavirus" + 0.089*"colorado" + 0.084*"covid" + 0.078*"trend" + 0.070*"wit
h" + 0.047*"los" + 0.047*"angeles" + 0.039*"alaska" + 0.034*"va"')
(15, '0.387*"florida" + 0.141*"covid" + 0.121*"dashboard" + 0.115*"coronavirus" + 0.044*"utah" + 0.039*"on" +
0.034*"mn" + 0.031*"quarantine" + 0.028*"connecticut" + 0.012*"coronovirus"')
(19, '0.395*"of" + 0.193*"coronavirus" + 0.062*"stimulus" + 0.054*"georgia" + 0.036*"vegas" + 0.033*"las" +
0.024*"check" + 0.022*"oggi" + 0.017*"number" + 0.015*"island"')
(7, '0.327*"is" + 0.163*"coronavirus" + 0.080*"contact" + 0.078*"delaware" + 0.056*"tracing" + 0.043*"locatio
ns" + 0.032*"spread" + 0.027*"buy" + 0.024*"jhu" + 0.015*"training"')
(26, '0.246*"ohio" + 0.144*"coronavirus" + 0.100*"covid" + 0.079*"montana" + 0.073*"ga" + 0.068*"in" + 0.066
*"louisiana" + 0.048*"nebraska" + 0.024*"sacramento" + 0.024*"plasma"')
(4, '0.552*"update" + 0.277*"coronavirus" + 0.033*"ny" + 0.019*"china" + 0.017*"india" + 0.013*"mississippi"
+ 0.013*"symptom" + 0.012*"brazil" + 0.011*"trends" + 0.009*"copper"')
(13, '0.441*"for" + 0.237*"coronavirus" + 0.120*"masks" + 0.110*"2020" + 0.014*"kids" + 0.008*"bay" + 0.007
*"medicine" + 0.006*"diarrhea" + 0.006*"george" + 0.006*"area"')
(5, '0.186*"arizona" + 0.156*"coronavirus" + 0.117*"a" + 0.101*"illinois" + 0.084*"reopening" + 0.064*"relie
f" + 0.053*"kansas" + 0.050*"tn" + 0.022*"ri" + 0.018*"bill"')
(24, '0.201*"deaths" + 0.161*"coronavirus" + 0.148*"usa" + 0.117*"covid" + 0.058*"in" + 0.051*"wisconsin" +
0.048*"by" + 0.026*"act" + 0.023*"country" + 0.020*"italia"')
(21, '0.294*"health" + 0.194*"department" + 0.092*"county" + 0.080*"coronavirus" + 0.073*"sweden" + 0.068*"n
c" + 0.045*"contra" + 0.044*"costa" + 0.024*"data" + 0.014*"policy"')
(9, '0.210*"coronavirus" + 0.195*"updates" + 0.125*"indiana" + 0.106*"tracker" + 0.058*"live" + 0.048*"tx" +
0.040*"kentucky" + 0.037*"regione" + 0.027*"campania" + 0.018*"login"')
(25, '0.399*"cases" + 0.272*"in" + 0.147*"covid" + 0.100*"coronavirus" + 0.024*"az" + 0.014*"minnesota" + 0.0
08*"rules" + 0.005*"bonus" + 0.005*"baby" + 0.004*"my"')
(11, '0.263*"texas" + 0.214*"san" + 0.134*"coronavirus" + 0.111*"pa" + 0.060*"diego" + 0.032*"antonio" + 0.03
2*"hours" + 0.031*"latest" + 0.026*"it" + 0.017*"bollettino"')
(14, '0.163*"numbers" + 0.151*"states" + 0.145*"covid" + 0.134*"coronavirus" + 0.088*"death" + 0.056*"united"
+ 0.036*"gov" + 0.035*"jersey" + 0.032*"wv" + 0.025*"dakota"')
(22, '0.206*"coronavirus" + 0.201*"symptoms" + 0.166*"virginia" + 0.101*"nj" + 0.045*"ct" + 0.040*"in" + 0.03
3*"wyoming" + 0.028*"nm" + 0.025*"wa" + 0.016*"pierce"')
(6, '0.455*"coronavirus" + 0.382*"county" + 0.039*"orange" + 0.022*"city" + 0.022*"ca" + 0.018*"fl" + 0.010
*"flu" + 0.008*"vs" + 0.008*"md" + 0.005*"current"')
(28, '0.253*"coronavirus" + 0.227*"new" + 0.191*"statistics" + 0.101*"and" + 0.071*"york" + 0.031*"trump" +
0.026*"pennsylvania" + 0.021*"type" + 0.010*"russia" + 0.008*"time"')
```

Topic 13 appears to be discussing the use of masks for coronavirus, particularly in 2020 and for kids and topic 12 seems to focus on travel restrictions related to COVID-19 with specific mentions of Alabama and Hawaii. Overall, provides good overview of the general things people were searching for, but could be improved by removing stopwords.

Conclusion

This project used several NLP techniques to understand the different things people were searching on the internet related to Covid 19 during June 2020. This project used NLP libraries and pretrained models (NLTK, transformers, and Gensim and Spacy). I applied the following topics to explore this dataset: NER, POS, Word2Vec, Tokenization, LDA and BOW. I implemented the following NLP applications: text summarization and sentiment analysis.

I really enjoyed experimenting with the text summarization capabilities of the HuggingFace transformer library. I was able to get a good overview of search activity during a month in 2020; however, better stopwords that are specific to this dataset, such as "covid" would improve this dataset by removing the words that are implicit given the nature of the data. Also removing sites using regular expressions would help the understandability of the results. Word2Vec overall provided such a great way to segment the search queries at scale but more exploration on the optimal number of clusters is needed.

```
In [ ]:
```