Assignment 6: Text Analytics: String Distances

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In [4]:
```
# Loading the necessary libraries
import pandas as pd
import numpy as np
import re
import matplotlib.pyplot as plt
import jellyfish
```

In [5]:
```
input_name = "Mukund" # initializing my name
```

In [6]:
```
babynames = pd.read_csv("babyNamesUSYOB-full.csv") # Loading the babynames dataset
```

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

Out[7]:

	YearOfBirth	Name	Sex	Number
0	1880	Mary	F	7065
1	1880	Anna	F	2604
2	1880	Emma	F	2003
3	1880	Elizabeth	F	1939
4	1880	Minnie	F	1746

In [8]:
```
babynames.shape
```

Out[8]:
```
(1858689, 4)
```

In [9]:
```
# Preprocessing the babynames data
names = babynames['Name'].apply(lambda x: re.sub('[^a-zA-Z]', '', x.lower())).drop_dup
```

In [10]:
```
# defining the distance metrics

def hamming_distance(a, b):
    """Computes the Hamming distance between two strings."""
    if len(a) != len(b):
        raise ValueError("Strings must be of equal length.")
    return sum(1 for x, y in zip(a, b) if x != y)


def longest_common_substring_distance(a, b):
    """Computes the distance between two strings as the length of their longest commor
    lengths = np.zeros((len(a) + 1, len(b) + 1))
    for i, x in enumerate(a):
        for j, y in enumerate(b):
            if x == y:
```

```python
                lengths[i + 1][j + 1] = lengths[i][j] + 1
    return len(a) + len(b) - 2 * lengths.max()


def levenshtein_distance(a, b):
    """Computes the Levenshtein distance between two strings."""
    return jellyfish.levenshtein_distance(a, b)


def damerau_levenshtein_distance(a, b):
    """Computes the full Damerau-Levenshtein distance between two strings."""
    return jellyfish.damerau_levenshtein_distance(a, b)


def restricted_damerau_levenshtein_distance(s1, s2):
    # Compute the standard Damerau-Levenshtein distance
    d = jellyfish.damerau_levenshtein_distance(s1, s2)

    # Count the number of adjacent transpositions
    transpositions = 0
    for i in range(min(len(s1), len(s2)) - 1):
        if s1[i] != s2[i] and s1[i+1] == s2[i] and s1[i] == s2[i+1]:
            transpositions += 1

    # Subtract the number of adjacent transpositions
    d_restricted = d - transpositions

    return d_restricted


def qgram_distance(a, b, q):
    """Computes the q-gram distance between two strings."""
    a_qgrams = set(a[i:i + q] for i in range(len(a) - q + 1))
    b_qgrams = set(b[i:i + q] for i in range(len(b) - q + 1))
    return 1 - len(a_qgrams & b_qgrams) / len(a_qgrams | b_qgrams)


def jaro_distance(a, b):
    """Computes the Jaro distance between two strings."""
    return jellyfish.jaro_distance(a, b)


def jaro_winkler_distance(a, b, weight=0.1):
    """Computes the Jaro-Winkler distance between two strings."""
    return jellyfish.jaro_winkler(a, b)


def jaccard_distance(a, b, q):
    """Computes the Jaccard distance between two strings based on their q-gram profile
    a_qgrams = set(a[i:i + q] for i in range(len(a) - q + 1))
    b_qgrams = set(b[i:i + q] for i in range(len(b) - q + 1))
    return 1 - len(a_qgrams & b_qgrams) / len(a_qgrams | b_qgrams)


def cosine_distance(a, b, q):
    """Computes the cosine distance between two strings based on their q-gram profiles
    a_qgrams = set(a[i:i + q] for i in range(len(a) - q + 1))
    b_qgrams = set(b[i:i + q] for i in range(len(b) - q + 1))
    intersection = len(a_qgrams & b_qgrams)
    norm_a = np.sqrt(len(a_qgrams))
```

```
    norm_b = np.sqrt(len(b_qgrams))
    return 1 - intersection / (norm_a * norm_b)


def soundex_distance(a, b):
    """Computes the distance between two strings based on their Soundex encoding."""
    soundex_a = jellyfish.soundex(a)
    soundex_b = jellyfish.soundex(b)
    return 0 if soundex_a == soundex_b else 1
```

In [11]:

```
def name_distance(name, distance_metric):
    """Computes the distance between the input name and another name based on a given
    return distance_metric(input_name, name)
```

In [12]:

```
# Computing the distance between the input name and each name in the dataset based on
# babynames['hamming_distance'] = names.apply(lambda x: name_distance(x, hamming_dista
babynames['longest_common_substring_distance'] = names.apply(lambda x: name_distance(x
babynames['levenshtein_distance'] = names.apply(lambda x: name_distance(x, levenshtein
babynames['damerau_levenshtein_distance'] = names.apply(lambda x: name_distance(x, dam
babynames['restricted_damerau_levenshtein_distance'] = names.apply(lambda x: name_dist
babynames['qgram_distance'] = names.apply(lambda x: name_distance(x, lambda a, b: qgra
babynames['jaro_distance'] = names.apply(lambda x: name_distance(x, jaro_distance))
babynames['jaro_winkler_distance'] = names.apply(lambda x: name_distance(x, jaro_winkl
babynames['jaccard_distance'] = names.apply(lambda x: name_distance(x, lambda a, b: ja
babynames['cosine_distance'] = names.apply(lambda x: name_distance(x, lambda a, b: cos
babynames['soundex_distance'] = names.apply(lambda x: name_distance(x, soundex_distanc
```

In [14]:

```
# Sorting the dataframes by each distance metric and selecting the top ten names
# top10_hamming = babynames.sort_values('hamming_distance').head(10)['Name']
top10_lcs = babynames.sort_values('longest_common_substring_distance').head(10)['Name'
top10_levenshtein = babynames.sort_values('levenshtein_distance').head(10)['Name']
top10_dl = babynames.sort_values('damerau_levenshtein_distance').head(10)['Name']
top10_restricted_dl = babynames.sort_values('restricted_damerau_levenshtein_distance')
top10_qgram = babynames.sort_values('qgram_distance').head(10)['Name']
top10_jaro = babynames.sort_values('jaro_distance', ascending=False).head(10)['Name']
top10_jaro_winkler = babynames.sort_values('jaro_winkler_distance', ascending=False).h
top10_jaccard = babynames.sort_values('jaccard_distance').head(10)['Name']
top10_cosine = babynames.sort_values('cosine_distance').head(10)['Name']
top10_soundex = babynames.sort_values('soundex_distance').head(10)['Name']

# Printing the top ten names for each distance metric
# print('Top 10 names based on Hamming distance:')
# print(top10_hamming)
# print('')

print('Top 10 names based on longest common substring distance:')
print(top10_lcs)
print('')

print('Top 10 names based on Levenshtein distance:')
print(top10_levenshtein)
print('')

print('Top 10 names based on full Damerau-Levenshtein distance:')
print(top10_dl)
print('')

print('Top 10 names based on restricted Damerau-Levenshtein distance:')
print(top10_restricted_dl)
```

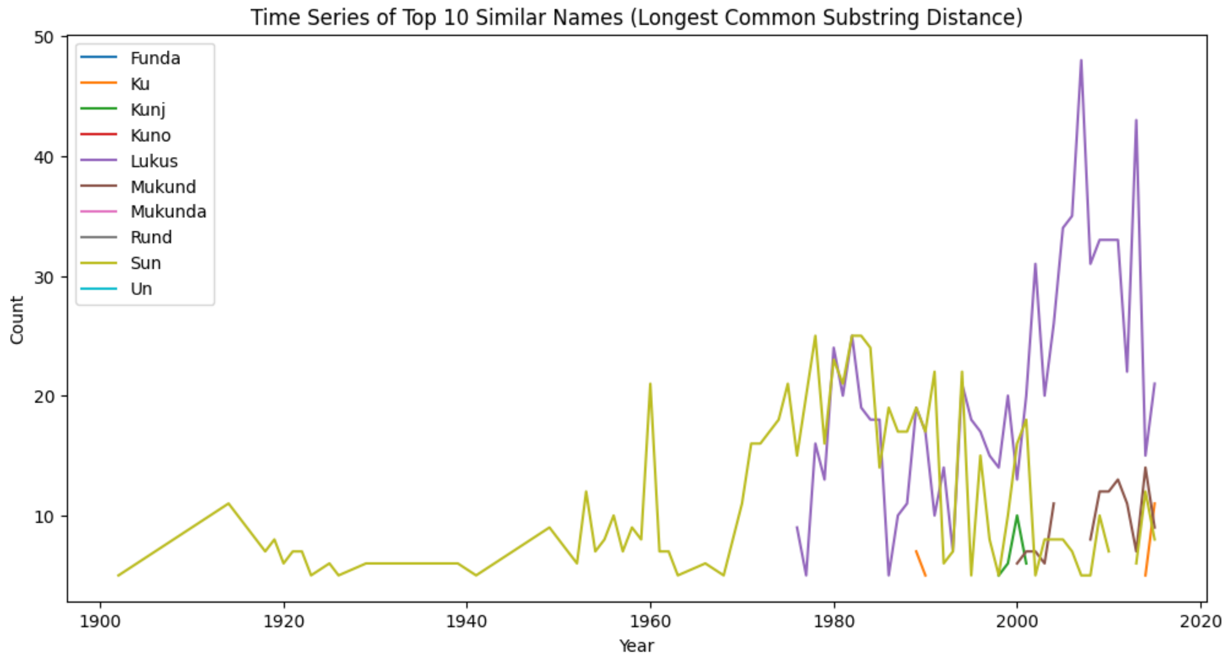
```
print('')

print('Top 10 names based on q-gram distance:')
print(top10_qgram)
print('')

print('Top 10 names based on Jaro distance:')
print(top10_jaro)
print('')

print('Top 10 names based on Jaro-Winkler distance:')
print(top10_jaro_winkler)
print('')

print('Top 10 names based on Jaccard distance:')
print(top10_jaccard)
print('')

print('Top 10 names based on cosine distance:')
print(top10_cosine)
print('')

print('Top 10 names based on Soundex distance:')
print(top10_soundex)
```

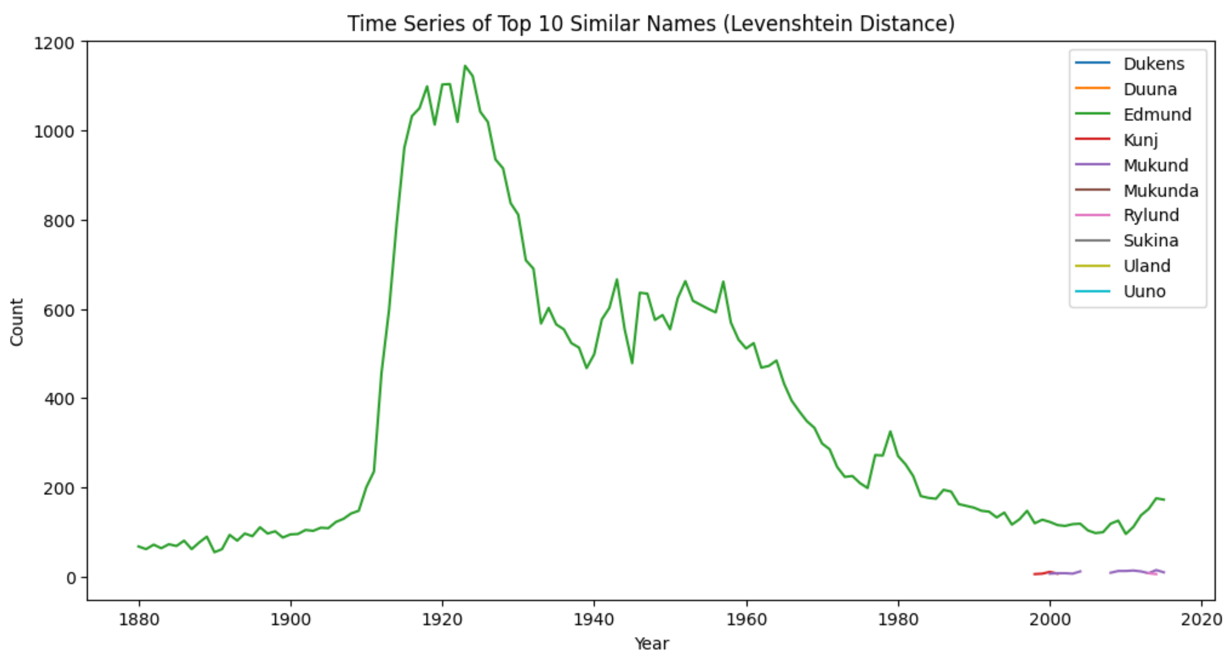
```
Top 10 names based on longest common substring distance:
1272422     Mukund
1858055    Mukunda
1587092       Kuno
1303322       Kunj
1001470         Ku
835026          Un
1405960       Rund
805735       Lukus
62489          Sun
734248       Funda
Name: Name, dtype: object

Top 10 names based on Levenshtein distance:
1272422     Mukund
1858055    Mukunda
725904       Uland
1303322       Kunj
1689414     Rylund
625751       Duuna
1128        Edmund
1452989     Dukens
720816      Sukina
179470        Uuno
Name: Name, dtype: object

Top 10 names based on full Damerau-Levenshtein distance:
1272422     Mukund
1858055    Mukunda
179470        Uuno
1318435     Yukino
720816      Sukina
1303322       Kunj
547798      Osmund
1505530     Yukina
118981      Eugune
1711226      Yuuna
Name: Name, dtype: object

Top 10 names based on restricted Damerau-Levenshtein distance:
1272422     Mukund
185676       Ikuko
1858055    Mukunda
1380291      Yuuka
922049      Nikunj
1484079      Mukul
625751       Duuna
1331942      Luken
1587092       Kuno
720816      Sukina
Name: Name, dtype: object

Top 10 names based on q-gram distance:
1272422     Mukund
1858055    Mukunda
1777325    Kundana
1303322       Kunj
1587092       Kuno
1405960       Rund
101680       Lunda
```

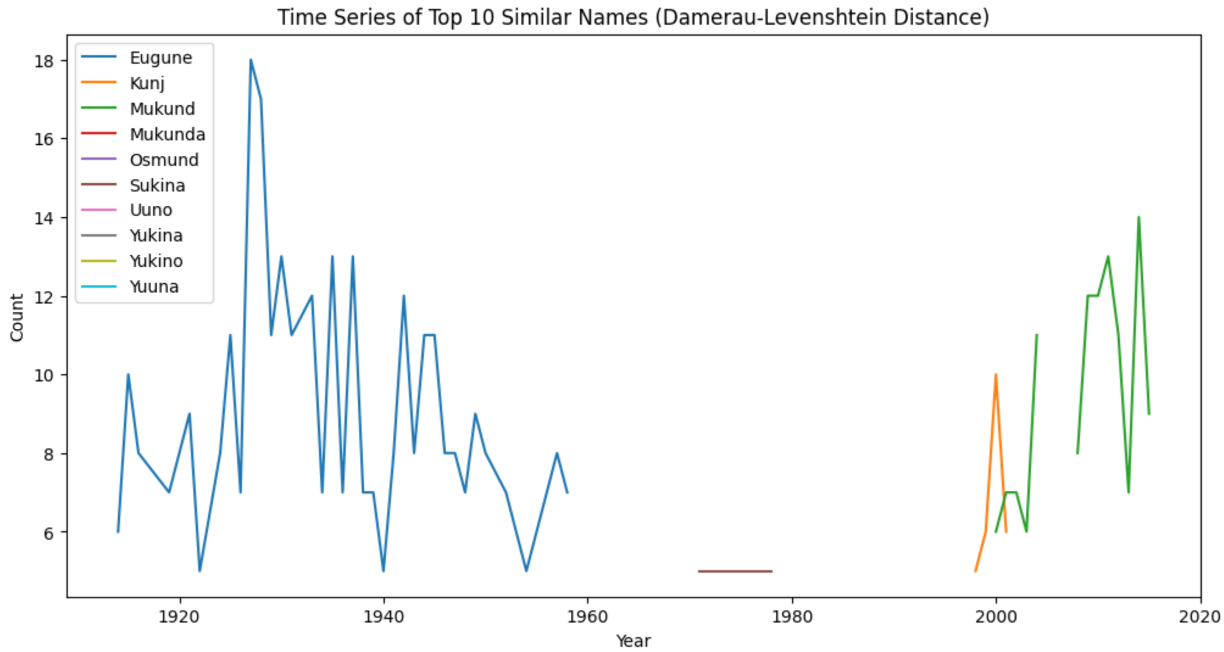
```
704285       Mundy
1044456      Tunde
15887        Gunda
Name: Name, dtype: object

Top 10 names based on Jaro distance:
1272422      Mukund
1858055     Mukunda
1405960        Rund
179470         Uuno
721013      Yulunda
757396        Kindu
941209        Kendu
919282     Chukwudi
718862     Burgundy
1036098    Katelund
Name: Name, dtype: object

Top 10 names based on Jaro-Winkler distance:
1272422      Mukund
1858055     Mukunda
1405960        Rund
179470         Uuno
721013      Yulunda
757396        Kindu
941209        Kendu
919282     Chukwudi
718862     Burgundy
1036098    Katelund
Name: Name, dtype: object

Top 10 names based on Jaccard distance:
1272422     Mukund
1858055    Mukunda
1777325    Kundana
1303322       Kunj
1587092       Kuno
1405960       Rund
101680       Lunda
704285       Mundy
1044456      Tunde
15887        Gunda
Name: Name, dtype: object

Top 10 names based on cosine distance:
1272422     Mukund
1858055    Mukunda
1777325    Kundana
1405960       Rund
1303322       Kunj
1587092       Kuno
657408       Rundy
1758444      Kunsh
1448640      Kunga
822179       Kunte
Name: Name, dtype: object

Top 10 names based on Soundex distance:
1272422       Mukund
1207957      Majenta
```

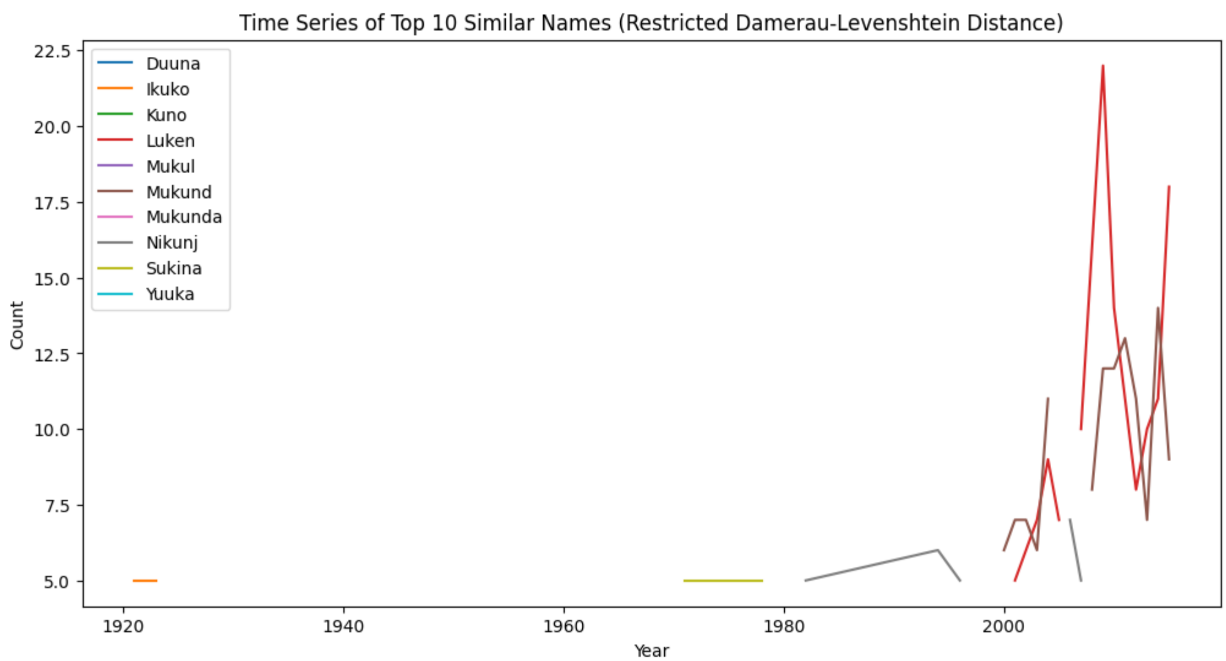
```
719346       Mashonda
875175        Magenta
835816       Mishonda
1285959      Makendra
933673      Mashaunda
677682       Mashanda
837281      Mashawnda
1405750      Mashanti
Name: Name, dtype: object
```

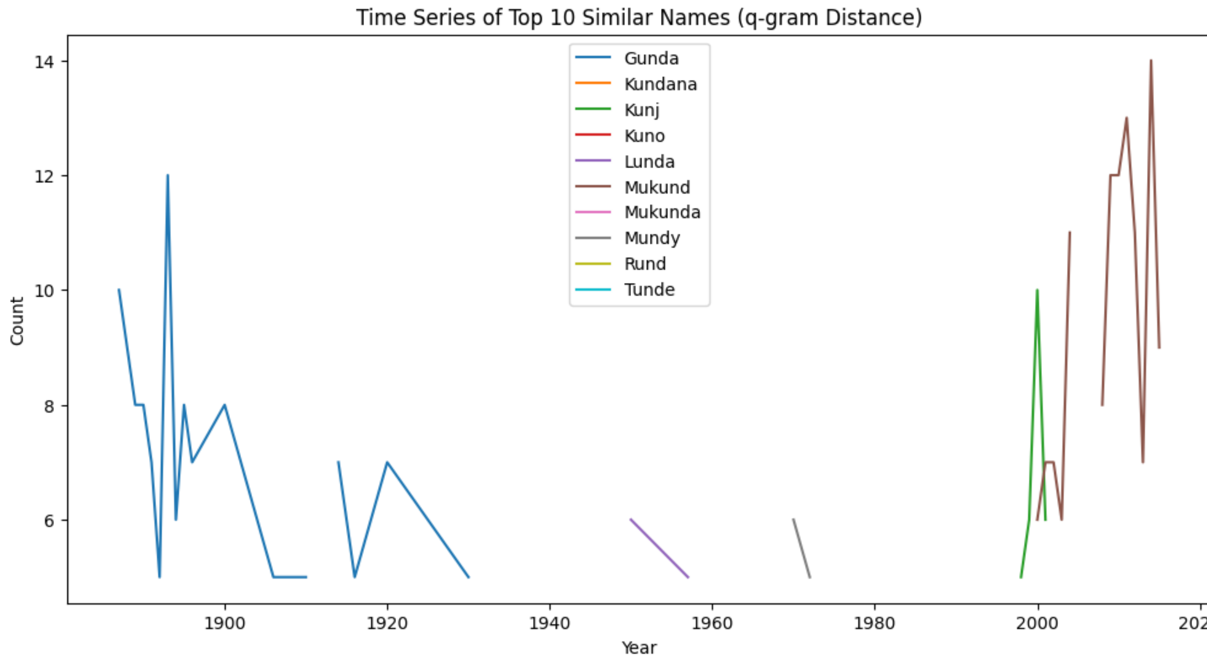
In [15]:
```python
# Plotting the time series
def plot_time_series(a, distance_metric):
    # Subset the data for the top 10 names
    subset = babynames[babynames['Name'].isin(a)]
    # subset = subset[subset['Name'] != input_name] # excluding the input name

    # Pivot the data to create a time series
    pivoted = subset.groupby(['YearOfBirth', 'Name'])['Number'].sum().unstack()

    # Plot
    pivoted.plot(figsize=(12,6))
    plt.title('Time Series of Top 10 Similar Names (' + distance_metric + ')')
    plt.xlabel('Year')
    plt.ylabel('Count')
    plt.legend()
    plt.show()

# Plotting the time series for each distance metric
# plot_time_series(top10_hamming, 'Hamming Distance')
plot_time_series(top10_lcs, 'Longest Common Substring Distance')
plot_time_series(top10_levenshtein, 'Levenshtein Distance')
plot_time_series(top10_dl, 'Damerau-Levenshtein Distance')
plot_time_series(top10_restricted_dl, 'Restricted Damerau-Levenshtein Distance')
plot_time_series(top10_qgram, 'q-gram Distance')
plot_time_series(top10_jaro, 'Jaro Distance')
plot_time_series(top10_jaro_winkler, 'Jaro-Winkler Distance')
plot_time_series(top10_jaccard, 'Jaccard Distance')
plot_time_series(top10_cosine, 'Cosine Distance')
plot_time_series(top10_soundex, 'Soundex Distance')
```

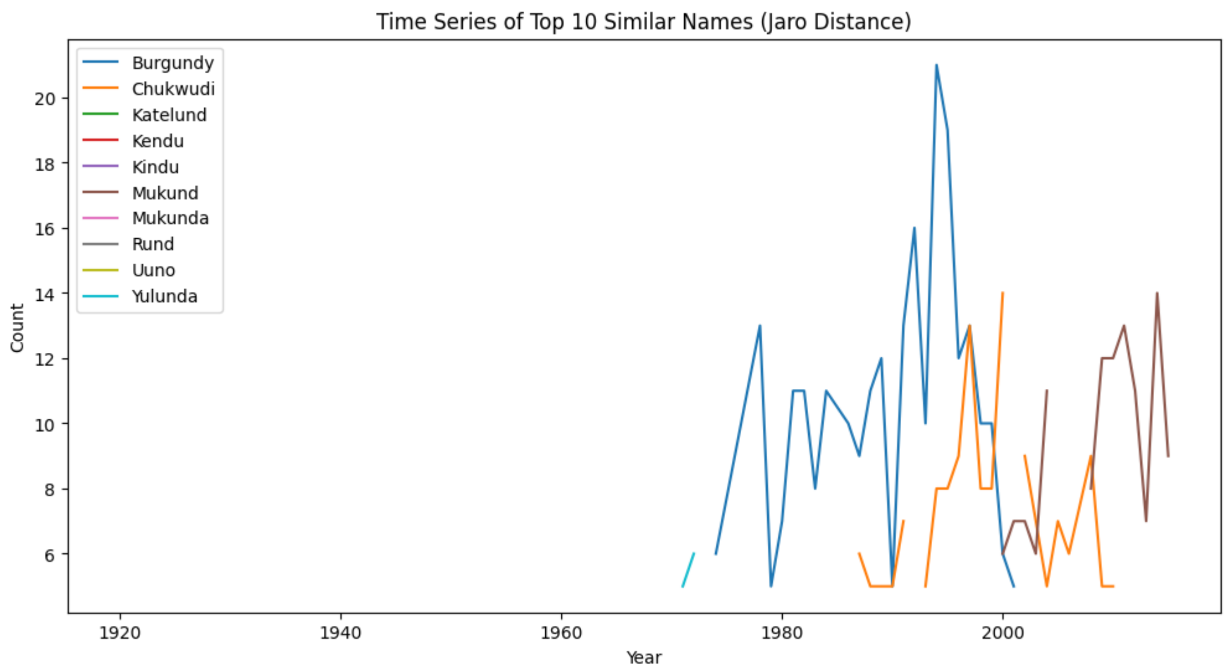

Time Series of Top 10 Similar Names (Longest Common Substring Distance)
Funda
Ku
Kunj
Kuno
Lukus
Mukund
Mukunda
Rund
Sun
Un
Count
Year
50
40
30
20
10
1900
1920
1940
1960
1980
2000
2020

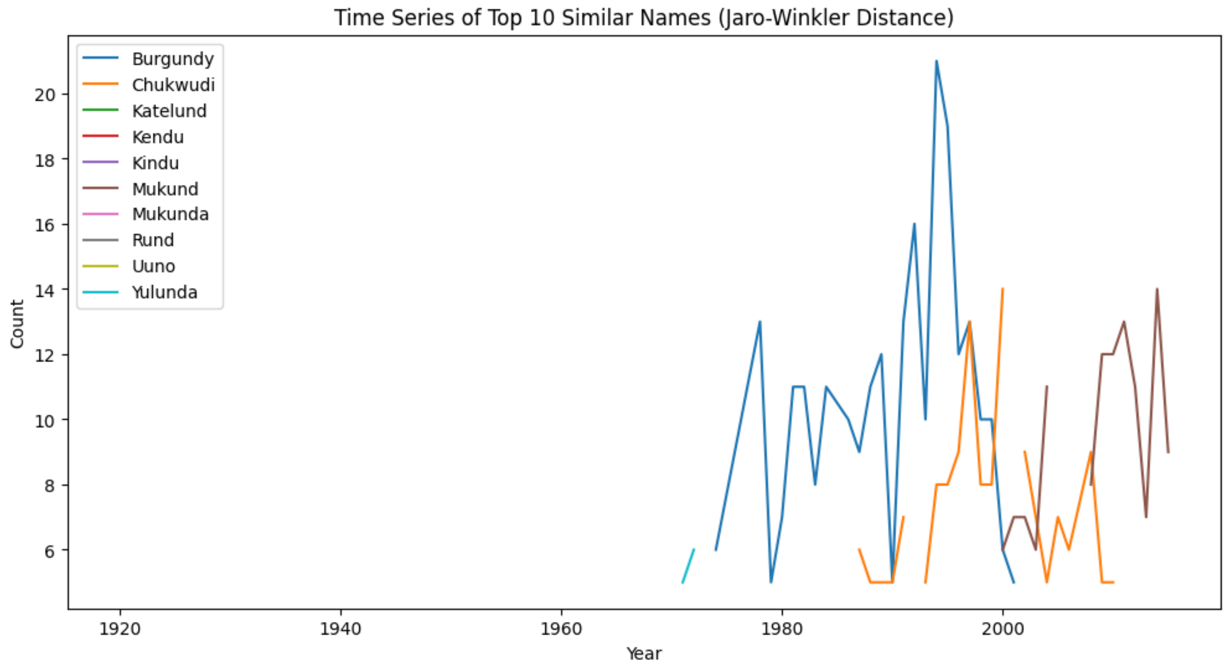

Time Series of Top 10 Similar Names (Levenshtein Distance)
Dukens
Duuna
Edmund
Kunj
Mukund
Mukunda
Rylund
Sukina
Uland
Uuno
Count
Year
1200
1000
800
600
400
200
0
1880
1900
1920
1940
1960
1980
2000
2020


Time Series of Top 10 Similar Names (Damerau-Levenshtein Distance)
Eugune
Kunj
Mukund
Mukunda
Osmund
Sukina
Uuno
Yukina
Yukino
Yuuna
Count
Year

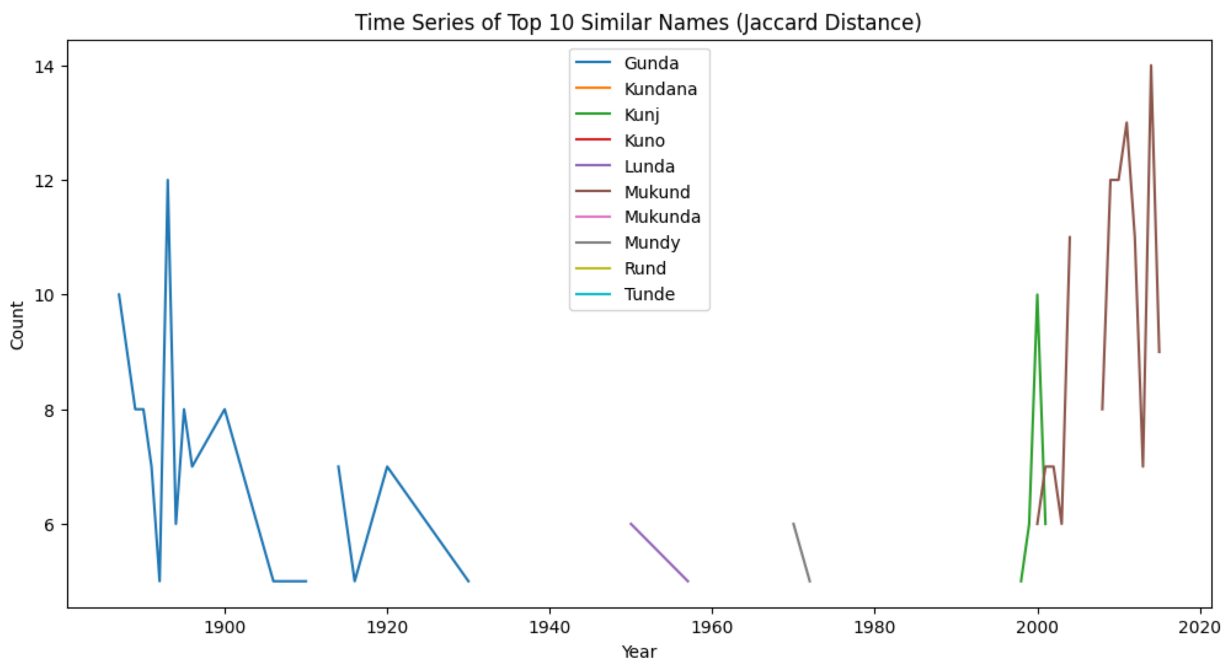

Time Series of Top 10 Similar Names (Restricted Damerau-Levenshtein Distance)
Duuna
Ikuko
Kuno
Luken
Mukul
Mukund
Mukunda
Nikunj
Sukina
Yuuka
Count
Year


Time Series of Top 10 Similar Names (q-gram Distance)
Gunda
Kundana
Kunj
Kuno
Lunda
Mukund
Mukunda
Mundy
Rund
Tunde
Count
Year
14
12
10
8
6
1900
1920
1940
1960
1980
2000
2020

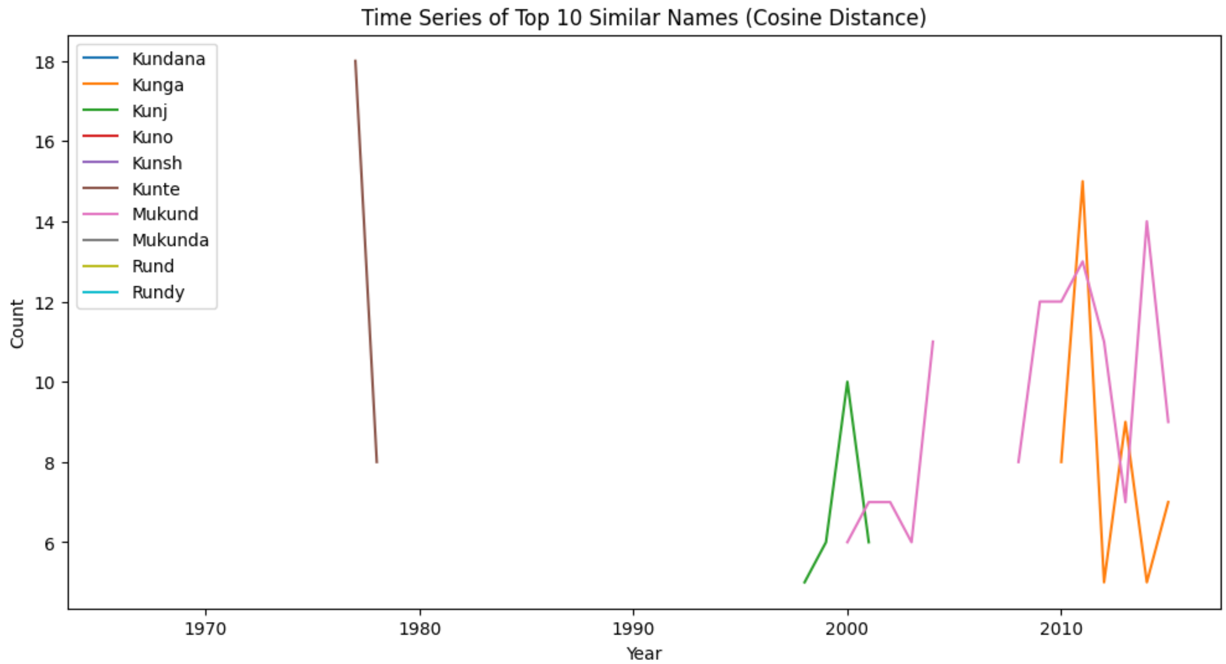

Time Series of Top 10 Similar Names (Jaro Distance)
Burgundy
Chukwudi
Katelund
Kendu
Kindu
Mukund
Mukunda
Rund
Uuno
Yulunda
Count
Year
20
18
16
14
12
10
8
6
1920
1940
1960
1980
2000

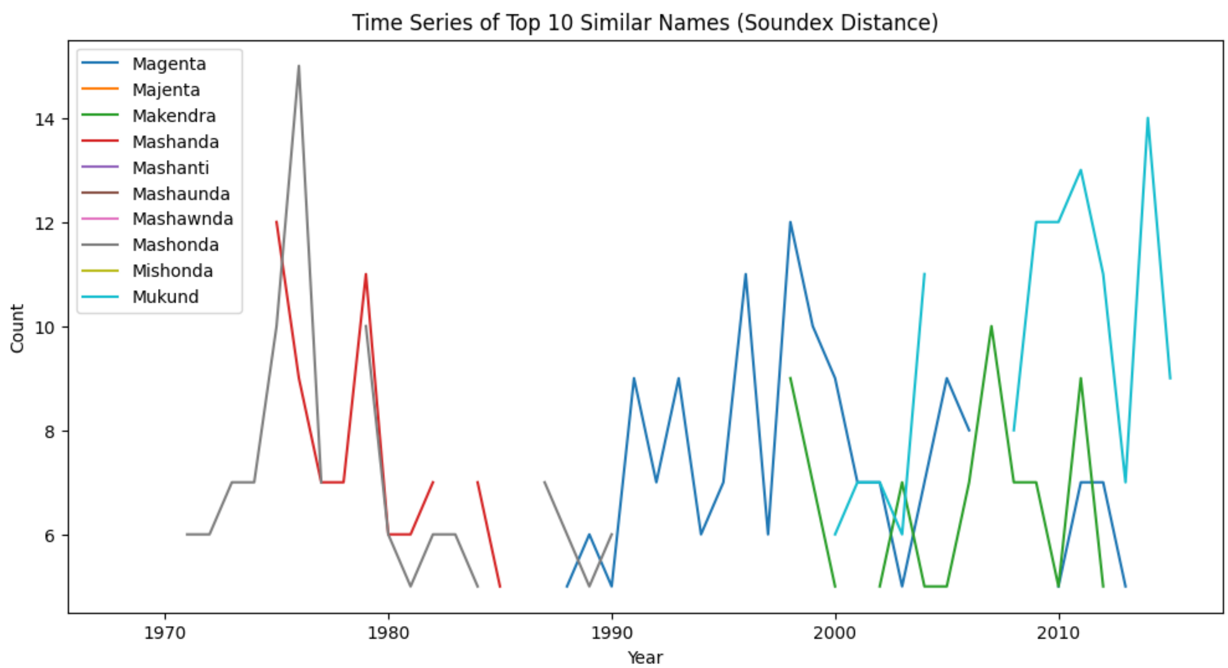


Time Series of Top 10 Similar Names (Jaro-Winkler Distance)
Burgundy
Chukwudi
Katelund
Kendu
Kindu
Mukund
Mukunda
Rund
Uuno
Yulunda
Count
Year



Time Series of Top 10 Similar Names (Jaccard Distance)
Gunda
Kundana
Kunj
Kuno
Lunda
Mukund
Mukunda
Mundy
Rund
Tunde
Count
Year





It is easy to note that the first name "Mukund" is not so common in the US and it has only started to appear after the 2000s. The "babynames" dataset consists of a large collection of names and their frequency of occurrence over the years. Therefore, the distance metrics that work well with longer strings and are capable of taking into account the semantic meaning of the symbols are likely to perform better on this dataset. Regarding which distance metrics to use for finding the related baby names and their similarities and differences, following are my observations:

The Levenshtein distance, Full Damerau-Levenshtein distance, and q-gram distance are examples of metrics that work well with longer strings and are capable of taking into account the semantic meaning of the symbols. The Levenshtein distance and Full Damerau-Levenshtein distance are capable of handling the insertion, deletion, and substitution of symbols in a string, which is especially useful for measuring the distance between names with different lengths or with common phonemes but different spellings. The q-gram distance, on the other hand, breaks the names into substrings of a fixed length, which helps to capture the semantic meaning of the symbols and is less sensitive to the order of the symbols.

The Longest Common Substring distance and Jaro distance, while still useful, may not be as effective on this dataset due to the large variation in the length of names and the high degree of variation in the order of the symbols. However, the Jaro-Winkler distance, which gives more weight to the initial characters, may be more effective as it can capture the similarities between names that share a common prefix.

The Hamming distance, while useful in certain contexts, is not as applicable to this dataset as it only works on strings of the same length, and doesn't take into account the semantic meaning of the symbols.

The Jaccard distance and cosine distance between q-gram profiles, while useful for comparing the similarity of short strings, may not be the best choice for the babynames dataset, as names can vary significantly in length, and the size of the q-grams may need to be adjusted to ensure accurate results.

Finally, the distance based on Soundex encoding is useful for comparing the similarity of names that sound alike but are spelled differently. It can help to identify common phonemes and group similar sounding names together, but it may not be as effective in capturing the semantic meaning of the symbols as some of the other distance metrics.