```
[1] import pandas as pd
    import seaborn as sns
    import matplotlib.pyplot as plt
    %matplotlib inline
    import warnings
    warnings.filterwarnings('ignore')
    import numpy as np
    import re
```

Project Introduction

Overview

In today's competitive job market, indiscriminately applying to every available job posting is not only futile but also inefficient. A more strategic approach involves identifying job opportunities that align with an individual's specific skill set, thereby increasing the chances of the resume being shortlisted by Application Tracking Systems (ATS). This project aims to address this challenge by developing a recommender system that matches job seekers with the most relevant job postings based on their resumes.

Project Goals

- **Objective**: To build a recommender system that informs job seekers of the best job opportunities aligned with their skills and experiences.
- **Target**: Enhance job application effectiveness by ensuring resumes are matched with suitable job postings, potentially increasing interview chances.

Current Status

- **Progress**: We are on track with our initial goals and the project scope remains unchanged.
- **Insights**: The problem statement's open-ended nature has been acknowledged, leading to a structured plan for the upcoming phases of the project. Discussed at the end in up-coming work.

Notebook Content Overview

Datasets

The foundational dataset(s) for this project were sourced from Kaggle, featuring job listings scraped from LinkedIn across four major categories:

1. Data Analyst
2. Software Engineer
3. Data Scientist
4. Data Engineer

These categories encapsulate a substantial segment of the current Computer Science-related job market.

Methodology

Data Preparation

- **Data Wrangling and Exploratory Data Analysis (EDA)**: Initial data cleaning and exploration to understand dataset characteristics.
- **Job Location Processing**: Deriving a 'city' column from 'job_location' to facilitate geocode retrieval.
- **Geocode Retrieval**: Implementing a caching mechanism for efficient batch retrieval of geocodes to avoid service provider blocks.

Text Processing

Comprehensive text processing on `job_description` and `job_skills`, including:

- Tokenization
- Case normalization
- Stopword removal
- Punctuation handling
- Lemmatization
- Part-of-Speech (POS) tagging
- Vectorization

Modeling and Recommendations

- Utilization of `CountVectorizer` and `Tf-Idf Vectorizer` for text vectorization.
- Matching job vectors to resume text to calculate similarity scores and identify top-n job recommendations.
- Application of K-Nearest Neighbors (KNN) for refined job recommendations.
- Visualization of recommended jobs in comparison to a baseline resume using t-SNE, highlighting the proximity of job opportunities in a reduced dimensional space.

```
[ ] df_analyst = pd.read_csv("./master/data_analyst.csv")
    df_software = pd.read_csv("./master/software_engineering.csv")
    df_scientist = pd.read_csv("./master/data_scientist.csv")
    df_data = pd.read_csv("./master/data_engineer.csv")
```

```
[ ] # Merge all the DataFrames into a single DataFrame
    merged_dataframe = pd.concat([df_analyst, df_software, df_scientist, df_data], ignore_index=True)

    # Save the merged DataFrame to a new CSV file
    merged_dataframe.to_csv("./merged_jobs.csv", index=False)
```

```
[ ] df_master = pd.read_csv("./master/merged_jobs.csv")
```

Based on intial data exploration, following can be observed:

1. Presence of Null-values in job_summary and job_skills.
2. Presence of junk in job-description such as emoticons, symbols and invalid characters.
3. Over 32K rows of job postings.

```
[ ] df_master.shape
```

```
(32641, 11)
```

```
[ ] df_master.head()
```

	job_title	company	job_location	job_link	first_seen	search_city	search_country	job level	job_type	job_summary	job_skills
0	Data Analyst-SQL, Tableau	Zortech Solutions	Mountain View, CA	https://www.linkedin.com/jobs/data-analyst-jobs	2023-12-20	Bloomington	United States	Associate	Onsite	NaN	NaN
1	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	2023-12-20	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...
2	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	2023-12-20	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...

3	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	2023-12-20	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...
4	Senior HRIS Analyst (Timekeeping and Payroll)	Nordson Corporation	Greater Bloomington Area	https://www.linkedin.com/jobs/view/senior-hris...	2023-12-20	Bloomington	United States	Mid senior	Remote	Collaboration drives Nordson's success as a ma...	Workday HCM, UKG Dimensions, Ceridian Dayforce...

```
[ ] df_master.describe()
```

	job_title	company	job_location	job_link	first_seen	search_city	search_country	job level	job_type	job_summary	job_skills
count	32641	32641	32641	32641	32641	32641	32641	32641	32641	32230	31368
unique	13465	9150	3259	29331	3	960	7	2	3	24147	31244
top	Senior Software Engineer	Jobs for Humanity	United States	https://ca.linkedin.com/jobs/view/customer-ser...	2023-12-20	Greater London	United States	Mid senior	Onsite	Who is Recruiting from Scratch :\nRecruiting f...	Databricks, SQL, Python, PySpark, Azure Data F...
freq	794	805	598	3	17236	341	25283	26244	15707	136	7

> Since job_skills and job_summary are most important features for modelling, removing those with no information. Also fixing the job_countries text irregularities.

```
[ ] df_master.isna().sum()
```

```
job_title            0
company              0
job_location         0
job_link             0
first_seen           0
search_city          0
search_country       0
job level            0
job_type             0
job_summary        411
job_skills        1273
dtype: int64
```

```
[ ] df_master.dropna(inplace=True)
```

```
[ ] df_master.isna().sum()
```

```
job_title         0
company           0
job_location      0
job_link          0
first_seen        0
search_city       0
search_country    0
job level         0
job_type          0
job_summary       0
job_skills        0
dtype: int64
```

```
[ ] df_master.shape
```

```
(31368, 11)
```

```
[ ] df_master["search_country"].value_counts()
```

```
United States      24434
United Kingdom      2732
Canada              1779
Australia            810
 Canada              767
 United Kingdom      617
 Australia           229
Name: search_country, dtype: int64
```

```
[ ] df_master['search_country'] = df_master['search_country'].str.strip()
```

```
[ ] df_master["search_country"].value_counts()
```

```
United States     24434
United Kingdom     3349
Canada             2546
Australia          1039
Name: search_country, dtype: int64
```

```
[ ] df_master["job_title"].value_counts()
```

```
Senior Software Engineer                                793
Software Engineer                                       587
Data Analyst                                            572
Senior Data Engineer                                    531
Data Engineer                                           472
                                                       ...
Senior Business Systems Analyst, Finance Systems          1
Senior FMV Analyst                                        1
BCBA - Board Certified Behavior Analyst                   1
Treasury Analyst Senior                                   1
Installation Supervisor Data Cables / International Travel    1
Name: job_title, Length: 13155, dtype: int64
```

```
[ ] unique_list = []

    for col in df_master.columns:
        item = (col, df_master[col].nunique(), df_master[col].dtypes, df_master[col].unique())
        unique_list.append(item)

    unique_counts = pd.DataFrame(
        unique_list,
        columns=["Column", "Number_of_unique_values", "Type", "Unique_category"]
    ).sort_values(by="Number_of_unique_values")


    display(unique_counts)
```

The first_seen column serves no value for us. Removing it.

```
[ ] df_master.drop('first_seen', axis=1, inplace=True)
```

```
[ ] df_copy = df_master.copy()
```

```
[ ] df_master = df_copy
```

This section does the following:

1. Tries to extract city from the job_location.
2. For cities marked as unknown as result of (1), information is tried to extract via a custom script defined in cells below.

```
[ ] from geotext import GeoText
```

```
def extract_city_with_geotext(location):
    places = GeoText(location)
    cities = list(places.cities)
    return cities[0] if cities else 'Unknown'

df_master['city'] = df_master['job_location'].apply(extract_city_with_geotext)
```

```
df_master.head()
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city
1	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington
2	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington
3	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	Bloomington
4	Senior HRIS Analyst (Timekeeping and Payroll)	Nordson Corporation	Greater Bloomington Area	https://www.linkedin.com/jobs/view/senior-hris...	Bloomington	United States	Mid senior	Remote	Collaboration drives Nordson's success as a ma...	Workday HCM, UKG Dimensions, Ceridian Dayforce...	Unknown
5	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	Bloomington

```
unknown_city_rows = df_master[df_master['city'] == 'Unknown']
unknown_city_rows.count()
```

```
job_title         5847
company           5847
job_location      5847
job_link          5847
search_city       5847
search_country    5847
job level         5847
job_type          5847
job_summary       5847
job_skills        5847
city              5847
dtype: int64
```

```
known_countries = ['United States', 'Australia', 'Canada']
known_regions = ['England', 'Scotland', 'Wales', 'Northern Ireland']

known_states_us = [
    'AL', 'AK', 'AZ', 'AR', 'CA', 'CO', 'CT', 'DE', 'FL', 'GA',
    'HI', 'ID', 'IL', 'IN', 'IA', 'KS', 'KY', 'LA', 'ME', 'MD',
    'MA', 'MI', 'MN', 'MS', 'MO', 'MT', 'NE', 'NV', 'NH', 'NJ',
    'NM', 'NY', 'NC', 'ND', 'OH', 'OK', 'OR', 'PA', 'RI', 'SC',
    'SD', 'TN', 'TX', 'UT', 'VT', 'VA', 'WA', 'WV', 'WI', 'WY'
]

def refine_city_extraction(row):

    if row['city'] == 'Unknown':
        location = row['job_location']
        parts = [part.strip() for part in location.split(',')]
        if len(parts) == 2 and parts[1] in known_states_us:
            return parts[0]
        elif len(parts) == 3:
            return parts[0]

    return row['city']

df_master['city'] = df_master.apply(refine_city_extraction, axis=1)

print(df_master[['job_location', 'city']])
```

```
                              job_location             city
1                          Bloomington, IN       Bloomington
2                          Bloomington, IN       Bloomington
3                          Bloomington, IN       Bloomington
4                  Greater Bloomington Area           Unknown
5                          Bloomington, IN       Bloomington
...                                    ...              ...
32635  Northamptonshire, England, United Kingdom  Northamptonshire
32636          Brackley, England, United Kingdom         Brackley
32637       Northampton, England, United Kingdom       Northampton
32638     Milton Keynes, England, United Kingdom     Milton Keynes
32639            Manchester Area, United Kingdom           Unknown

[31368 rows x 2 columns]
```

1. Even after processing the cities, the left-over rows are dropped.
2. Number of unknown cities went from 5847 to 2217

```
unknown_city_count = df_master[df_master['city'] == 'Unknown']["job_location"].count()
print(f"Number of rows with 'Unknown' city: {unknown_city_count}")


df_master = df_master[df_master['city'] != 'Unknown']
df_master.reset_index(drop=True, inplace=True)

df_master.head()
```

```
Number of rows with 'Unknown' city: 2217
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	Bloomington
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	Bloomington
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	Laughlin AFB

1. Next we try to get the geocode of the cities.
2. Seeing the number of unique cities as 2569, it was better to cache the geocodes, to avoid repeated request for same city from API.

```
df_master["city"].nunique()
```

```
2569
```

```
from geopy.geocoders import Nominatim
from geopy.exc import GeocoderTimedOut, GeocoderUnavailable
from time import sleep
```

```
l = geolocator.geocode("Monrovia, CA")
```

```
[ ] len(geocode_cache)
```

```
1701
```

```
[ ] geolocator = Nominatim(user_agent="sauravjoshi_33@rediffmail.com")

    # Cache for storing city geocodes to avoid repeated requests
    geocode_cache = {}
```

```
[ ]
    def get_lat_lon(city):
        if city in geocode_cache:
            return geocode_cache[city]
        else:
            max_retries = 5
            retries = 0
            while retries < max_retries:
                try:
                    location = geolocator.geocode(city)
                    if location:
                        geocode_cache[city] = (location.latitude, location.longitude)
                        print(f"Found: {geocode_cache[city]}")
                        return geocode_cache[city]
                    else:
                        print(f"Not found: {city}")
                        geocode_cache[city] = (None, None)
                        return (None, None)
                except (GeocoderTimedOut, GeocoderUnavailable):
                    retries += 1
                    sleep_time = 5
                    print(f"Timeout or unavailable, retrying... ({retries}/{max_retries})")
                    sleep(sleep_time)
            return (None, None)

    def process_batch(cities):
        return cities.apply(get_lat_lon)

    # Batch processing
    batch_size = 1000
    for start in range(0, len(df_master), batch_size):
        end = start + batch_size
        df_master.loc[start:end, 'latitude_longitude'] = process_batch(df_master['job_location'][start:end])
        print(f"Processed batch {start//batch_size + 1}/{(len(df_master) - 1)//batch_size + 1}")
        sleep(1)

    print(df_master.head())
```

```
[ ] none_count = df_master['latitude_longitude'].apply(lambda x: x == (None, None)).sum()
    print(f"Number of (None, None) entries: {none_count}")
    print(df_master.shape)
```

```
Number of (None, None) entries: 397
(29147, 14)
```

```
[ ] df_master = df_processed_coordinates.copy()
```

```
[ ] df_processed_coordinates = df_master.copy()
    df_master = df_master[df_master['latitude_longitude'] != (None, None)]
    df_master.reset_index(drop=True, inplace=True)
    print(df_master.shape)
```

```
(28750, 14)
```

```
[ ] df_master.to_csv('./sample_data/coordinates_processed_merged.csv', index=False)
```

```
[2] df_master = pd.read_csv("./drive/MyDrive/418/coordinates_processed_merged.csv")
```

```
[3] df_master.head(2)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington	(39.1670396, -86.5342881)	39.16704	-86.534288
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington	(39.1670396, -86.5342881)	39.16704	-86.534288

Now as we have latitude_longitude, we try to extract some information out of the jobs posted.

```
[4] import folium
    from folium.plugins import HeatMap
```

```
[5] # df_master = df_processed_coordinates.copy()
```

```
[6] df_processed_coordinates = df_master.copy()
```

```
[7] df_master.head()
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	Laughlin AFB	(29.3614054, -100.778572)	29.361405	-100.778572

```
[8] df_master["latitude"][0]
```

```
39.1670396
```

Visualization 1: Saurav Joshi

1. This heatmap shows us the job locations which are present across different countries.
2. The jobs seems to be more concentrated over West & Mid-West of America than Easts, Almost entirety in Ausralia towards the East-coast, mostly in London, Manchester and Birmingham in UK and interestingly almost every job in Canada comes with a location at a closer

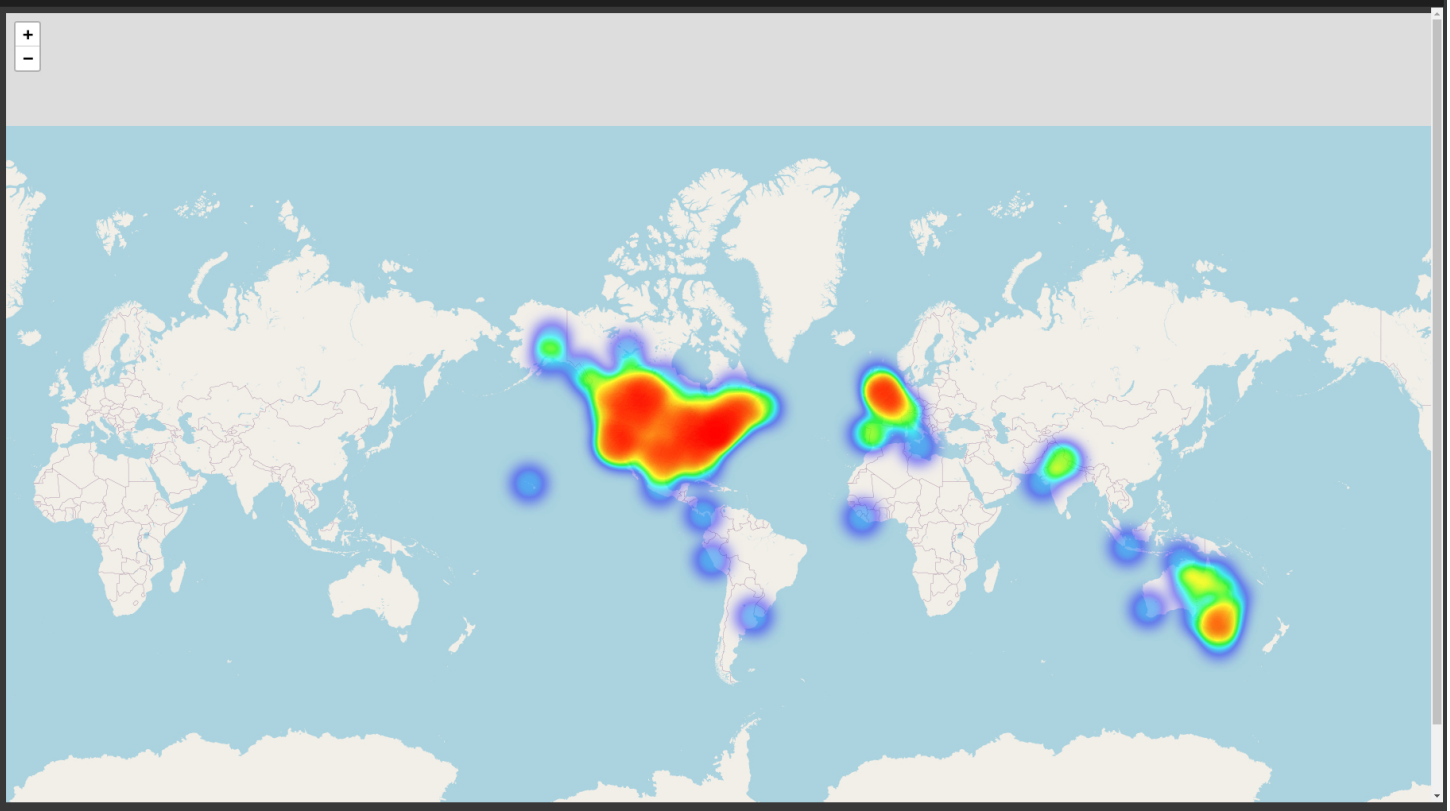
mostly in London, Manchester and Birmingham in UK and interestingly almost every job in Canada, comes with a location at a closer proximity with US such as at Vancouver and Montreal.

3. This visualization in-turn gives rise to know what jobs are prevalent in which regions.

```
[9] coords = df_master[['latitude', 'longitude']].values.tolist()
    map_center = [df_master['latitude'].mean(), df_master['longitude'].mean()]
    m2 = folium.Map(location=map_center, zoom_start=2)
    HeatMap(coords).add_to(m2)
```

```
<folium.plugins.heat_map.HeatMap at 0x7e781129a3e0>
```

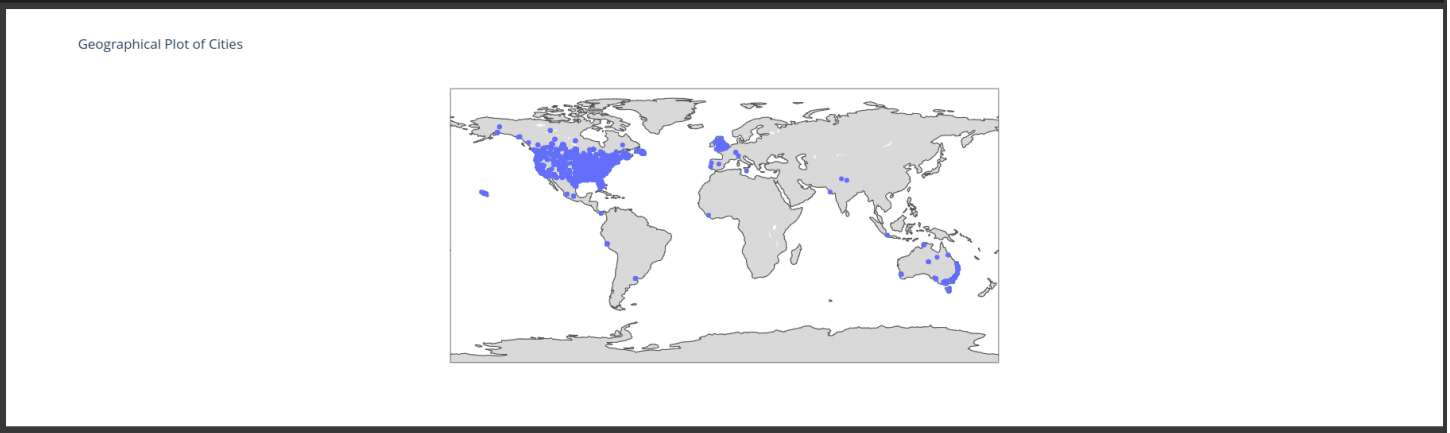
```
[10] m2
```



```
[11] # HeatMap(coords).add_to(m)
     map_file_path = './drive/MyDrive/418/heatmap.html'
     m2.save(map_file_path)

     map_file_path
```

```
'./drive/MyDrive/418/heatmap.html'
```

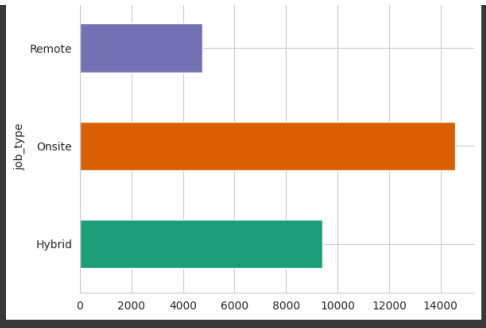
```
[12] import pandas as pd
     import plotly.express as px

     fig = px.scatter_geo(df_master,
                          lat='latitude',
                          lon='longitude',
                          title='Geographical Plot of Cities')

     fig.update_layout(showlegend=True, geo=dict(
         landcolor='rgb(217, 217, 217)',
     ))

     fig.show()
```



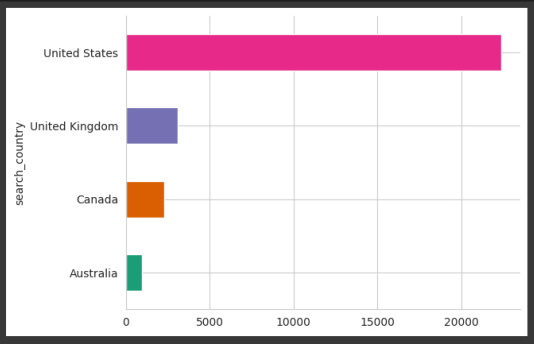

```
[ ]
```

Some more supportive visualizations for known the split of data on job_types and the countries they were searched from.

```
[ ] from matplotlib import pyplot as plt
    import seaborn as sns
    df_master.groupby('job_type').size().plot(kind='barh', color=sns.palettes.mpl_palette('Dark2'))
    plt.gca().spines[['top', 'right',]].set_visible(False)
```




```
[ ] from matplotlib import pyplot as plt
    import seaborn as sns
    df_master.groupby('search_country').size().plot(kind='barh', color=sns.palettes.mpl_palette('Dark2'))
    plt.gca().spines[['top', 'right',]].set_visible(False)
```




```
[ ] df_master.info()
```

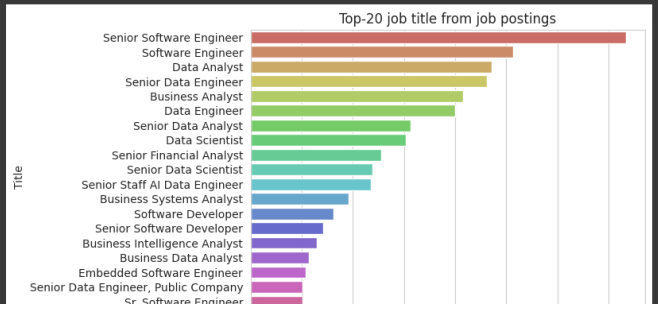
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 28750 entries, 0 to 28749
Data columns (total 14 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   job_title           28750 non-null  object
 1   company             28750 non-null  object
 2   job_location        28750 non-null  object
 3   job_link            28750 non-null  object
 4   search_city         28750 non-null  object
 5   search_country      28750 non-null  object
 6   job_level           28750 non-null  object
 7   job_type            28750 non-null  object
 8   job_summary         28750 non-null  object
 9   job_skills          28750 non-null  object
 10  city                28750 non-null  object
 11  latitude_longitude  28750 non-null  object
 12  latitude            28750 non-null  float64
 13  longitude           28750 non-null  float64
dtypes: float64(2), object(12)
memory usage: 3.1+ MB
```

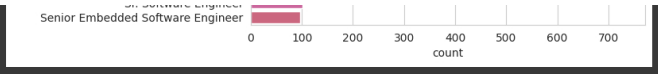
To get more information on job titles the irregularities present in the values of job_titles need to be handled.

```
[ ] df_master['job_title'].value_counts().head(25)
    # It can be seen that there are repetitions present like Senior Software Engineer and Sr. Software Engineer
    # Also Senior Data Analyst vs Sr. Data Analyst.
    # Such titles need to be handled and changed into a single category.
    # Not only these, some job title come along with name of company or some additional metadata which creates them as a new category.
```

```
Senior Software Engineer                                    735
Software Engineer                                           513
Data Analyst                                                471
Senior Data Engineer                                        463
Business Analyst                                            415
Data Engineer                                               400
Senior Data Analyst                                         313
Data Scientist                                              304
Senior Financial Analyst                                    256
Senior Data Scientist                                       238
Senior Staff AI Data Engineer                               235
Business Systems Analyst                                    192
Software Developer                                          162
Senior Software Developer                                   142
Business Intelligence Analyst                               129
Business Data Analyst                                       113
Embedded Software Engineer                                  108
Senior Data Engineer, Public Company                        101
Sr. Software Engineer                                       101
Senior Embedded Software Engineer                            97
Senior VAT and Indirect Tax Analyst                          97
Data Engineer - Scala(U.S. remote)                           91
Sr. Data Analyst                                             88
Data Research Analyst, gt.school (Remote) - $60,000/year USD 83
35F Intelligence Analyst                                     82
Name: job_title, dtype: int64
```

```
[ ] job_title = df_master["job_title"].value_counts().reset_index()[:20]
    job_title.columns = ["Title", "count"]

    sns.barplot(x="count", y="Title", data=job_title, color="blue", palette="hls").set(title="Top-20 job title from job postings");
```





Resolving Cases such as:

1. Resolve Sr. Data Engineer to Senior Data Engineer
2. Sr. Data Analyst to Senior Data Analyst
3. Or Data Engineer - Scala(U.S. remote) to Data Engineer
4. Senior Data Engineer, Public Company to Senior Data Engineer
5. Labs - Data Scientist - Senior Associate to Data Scientist
6. Data Analyst (Bangkok Based, relocation provided) to Data Analyst

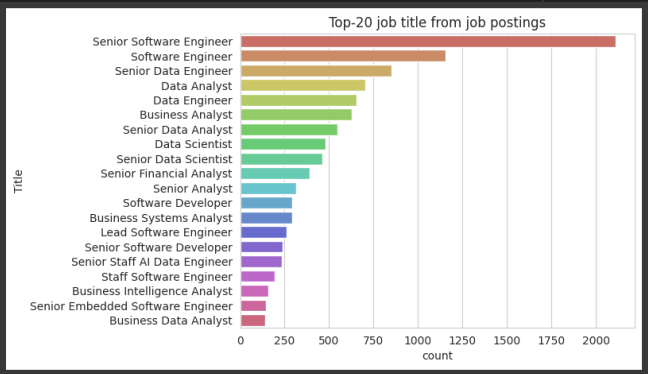
```
[ ] import re

    def normalize_job_title(title):

        title = title.replace('Sr.', 'Senior')
        title = re.sub(r'\bSDE\b', 'Software Development Engineer', title, flags=re.IGNORECASE)
        title = re.sub(r'\bSW Engineer\b', 'Software Engineer', title, flags=re.IGNORECASE)

        title = re.sub(r'\s*-\s*.*', '', title)
        title = re.sub(r'\s*,\s*.*', '', title)
        title = re.sub(r'\(.*\)', '', title)

        title = title.strip()
        title = re.sub(r'[^A-Za-z0-9\s\-,.]', '', title)

        return title

    df_master['normalized_job_title'] = df_master['job_title'].apply(normalize_job_title)


    print(df_master[['job_title', 'normalized_job_title']])
```

```
                                        job_title  \
0                    Market Research & Insights Analyst
1                          Business Systems Analyst `1
2                  Senior VAT and Indirect Tax Analyst
3              Business Intelligence Reporting Analyst 2
4                          Lead Senior Business Analyst
...                                             ...
28745  Customer Service Representative/Data Analyst/D...
28746                        HR Systems and Data Analyst
28747                         Senior Oracle Data Analyst
28748                            Data Governance Analyst
28749                  Energy Data and Forecast Analyst

                                normalized_job_title
0                     Market Research  Insights Analyst
1                           Business Systems Analyst 1
2                  Senior VAT and Indirect Tax Analyst
3              Business Intelligence Reporting Analyst 2
4                          Lead Senior Business Analyst
...                                             ...
28745  Customer Service RepresentativeData AnalystDat...
28746                        HR Systems and Data Analyst
28747                         Senior Oracle Data Analyst
28748                            Data Governance Analyst
28749                  Energy Data and Forecast Analyst

[28750 rows x 2 columns]
```

```
[ ] df_master['normalized_job_title'].value_counts().head(25)
```

```
Senior Software Engineer             2111
Software Engineer                    1155
Senior Data Engineer                  852
Data Analyst                          704
Data Engineer                         653
Business Analyst                      627
Senior Data Analyst                   549
Data Scientist                        482
Senior Data Scientist                 461
Senior Financial Analyst              389
Senior Analyst                        313
Software Developer                    294
Business Systems Analyst              294
Lead Software Engineer                262
Senior Software Developer             238
Senior Staff AI Data Engineer         236
Staff Software Engineer               193
Business Intelligence Analyst         158
Senior Embedded Software Engineer     143
Business Data Analyst                 142
Senior Business Analyst               128
Data Center Engineer                  128
Embedded Software Engineer            125
Principal Software Engineer           116
Lead Data Engineer                    112
Name: normalized_job_title, dtype: int64
```

```
[ ] job_title = df_master["normalized_job_title"].value_counts().reset_index()[:20]
    job_title.columns = ["Title", "count"]

    sns.barplot(x="count", y="Title", data=job_title, color="blue", palette="hls").set(title="Top-20 job title from job postings");
```




```
[ ] df_master.head()
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude	normalized_job_title
0	Market Research & Insights	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-	Data analysis, Market research,	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Market Research Insights Analyst

	Analyst	Foundation							performer ...	Survey develop...					
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Business Systems Analyst 1
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Senior VAT and Indirect Tax Analyst
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Business Intelligence Reporting Analyst 2
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	Laughlin AFB	(29.3614054, -100.778572)	29.361405	-100.778572	Lead Senior Business Analyst

```
[ ] df_2 = df_master.copy()
    # df_master = df_2.copy()
```

Visualization 2: Saurav Joshi

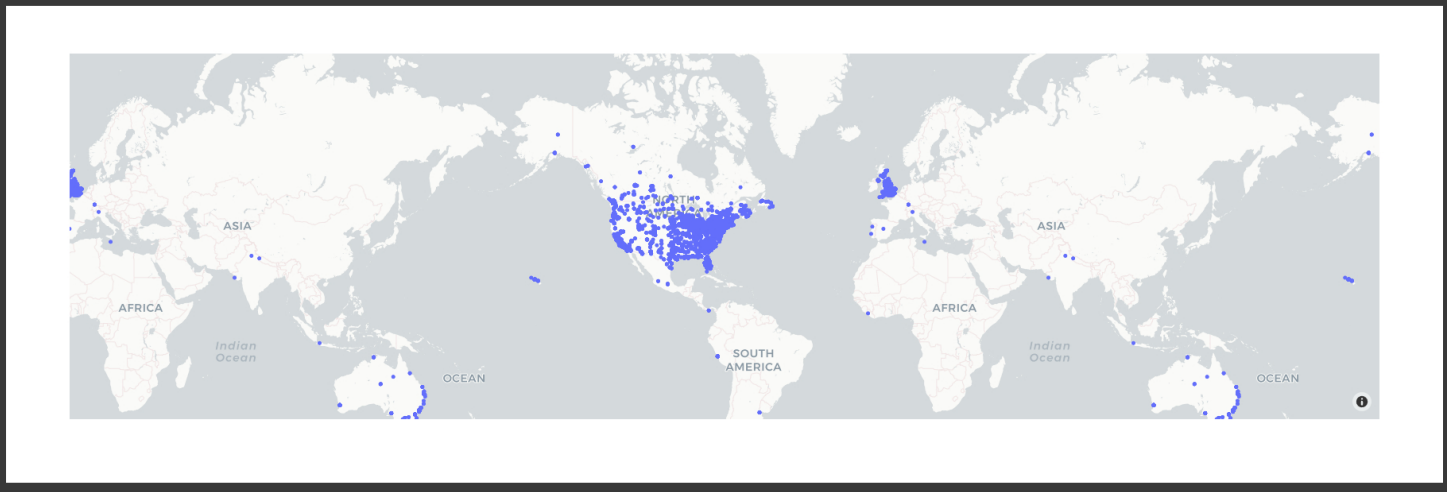
> Now since we have normalized_job_title, we can now investigate dominant jobs based on cities.
>
> - The concentration of points illustrates the relative number of jobs in each region, giving a visual representation of job availability and market demand.
> - The clusters of job points may correlate with economic centers and tech hubs, suggesting where certain industries are thriving.
> - This can allow candidates to target specific cities which are having more job postings as per their required job title.

```
[ ] dominant_jobs = df_master.groupby('latitude_longitude')['normalized_job_title'].agg(
        lambda x: x.value_counts().idxmax()).reset_index(name='dominant_job')
```

```
[ ] dominant_jobs.head()
```

	latitude_longitude	dominant_job
0	(-11.9547401, -77.0612044)	eCommerce Analyst
1	(-11.9862556, -77.0096138)	Senior Data Engineer
2	(-12.1106354, -77.0471789)	Business Intelligence Analyst
3	(-12.46044, 130.8410469)	Gi3 Senior Analyst
4	(-12.463508000000001, 130.84355545363502)	Business Analyst for a Period of 6 Months

```
[ ] df_master = pd.merge(df_master, dominant_jobs, on='latitude_longitude', how='left')
    fig = px.scatter_mapbox(df_master,
                            lat="latitude",
                            lon="longitude",
                            hover_name="dominant_job",
                            zoom=1,
                            height=600,
                            mapbox_style="carto-positron")

    fig.show()
```




```
[ ] # Next thing to do is Text-preprocessing. Primarily for Job description and Normalized job title column.
    # - tokenization
    # - case handling, stop word removal
    # - punctutation handling
    # - lemmatization
    # - POS tagging
    # - Vectorization

    import nltk
    nltk.download("stopwords")
    nltk.download('averaged_perceptron_tagger')
    nltk.download('punkt')
    nltk.download('wordnet')
    from nltk import word_tokenize, pos_tag, pos_tag_sents
    from nltk.corpus import wordnet
    from nltk.stem import WordNetLemmatizer
    from nltk.corpus import stopwords
    from string import punctuation
    from sklearn.feature_extraction.text import TfidfVectorizer
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data]     /root/nltk_data...
[nltk_data]   Unzipping taggers/averaged_perceptron_tagger.zip.
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data...
```

```
[ ] def text_preprocessing(data_master):

        data_master["job_skills_summary"] = data_master["job_skills_summary"].apply(lambda x: re.sub( r"([A-Z][^a-z]*)", r" \1", x))
        data_master["job_skills_summary"] = data_master["job_skills_summary"].str.lower()

        return data_master

    def get_pos(data_master):

        texts = data_master["job_skills_summary"].tolist()
        tagged_texts = pos_tag_sents(map(word_tokenize, texts))
        data_master["POS"] = tagged_texts

        return data_master


    def get_informative_token(data_master):

        pos_noninformative = [".", "CC", "CD", "DT", "IN", "LS", "MD", "POS", "PRP",
                              "PRP$", "TO", "UH", "WDT", "WP", "WP$", "WRB"]

        data_master["POS_clean"] = data_master["POS"].apply(lambda x: [pair for pair in x if pair[0] != "nbsp" and pair[1] not in pos_noninformative])

        return data_master


    def get_only_token(data_master):

        data_master["clean_token"] = data_master["POS_clean"].apply(lambda x: [word[0] for word in x])

        return data_master


    def get_count_of_tokens(data_master):

        data_master["token_number"] = data_master["clean_token"].apply(lambda x: len(x))

        return data_master
```

```
[ ] duplicates = df_master[df_master.duplicated(subset='job_summary', keep=False)]
    duplicates_sorted = duplicates.sort_values(by='job_summary')
    duplicates_sorted.head(4)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude	normalized_job_ti
23615	Remote - Senior Application Engineer (Data Sim...	TechFetch.com - On Demand Tech Workforce hirin...	Canonsburg, PA	https://www.linkedin.com/jobs/view/remote-seni...	Weirton	United States	Mid senior	Remote	"ALL our jobs are US based and candidates must...	Data Simulation, PLM, Aras Innovator, Siemens ...	Canonsburg	(40.2588431, -80.186732)	40.258843	-80.186732	Ren
25121	Remote - Senior Application Engineer (Data Sim...	TechFetch.com - On Demand Tech Workforce hirin...	Canonsburg, PA	https://www.linkedin.com/jobs/view/remote-seni...	Steubenville	United States	Mid senior	Remote	"ALL our jobs are US based and candidates must...	Data Simulation, PLM, Aras Innovator, Siemens ...	Canonsburg	(40.2588431, -80.186732)	40.258843	-80.186732	Ren
28708	Big Data Developer	ASK Consulting	Ridgefield Park, NJ	https://www.linkedin.com/jobs/view/big-data-de...	Greenwich	United States	Mid senior	Onsite	"All candidates must be directly contracted by...	SQL, Python, Spark, Hadoop, Kafka, Hive, Impal...	Ridgefield Park	(40.8570442, -74.0215285)	40.857044	-74.021529	Big Data Develo
20421	Big Data Developer	ASK Consulting	Ridgefield Park, NJ	https://www.linkedin.com/jobs/view/big-data-de...	Nyack	United States	Mid senior	Onsite	"All candidates must be directly contracted by...	SQL, Hive, Python, Spark, Hadoop, Kafka, Impal...	Ridgefield Park	(40.8570442, -74.0215285)	40.857044	-74.021529	Big Data Develo

```
[ ] df_master = df_master.drop_duplicates(subset=['job_summary'], keep='first')
```

```
[ ] df_master["job_summary"].duplicated().sum()
```

```
0
```

```
[ ] df_master['job_skills_summary'] =  df_master['job_skills'] + " " + df_master['job_summary']
```

```
[ ] df_master.head(2)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude	normalized_job_title
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington	(39.1670396, -86.5342881)	39.16704	-86.534288	Market Research Insights Analyst
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington	(39.1670396, -86.5342881)	39.16704	-86.534288	Business Systems Analyst 1

```
[ ] df_master = text_preprocessing(df_master)
```

```
[ ] df_master["job_skills_summary"].describe()
```

```
count                                                21926
unique                                               21926
top       data analysis,  market research,  survey deve...
freq                                                     1
Name: job_skills_summary, dtype: object
```

```
[ ] df_master = get_pos(df_master)
    df_master = get_informative_token(df_master)
    df_master = get_only_token(df_master)
    df_master = get_count_of_tokens(df_master)
```

```
[ ] df_master.head(10)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude	normalized_jo
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Market Researc
1	Business Systems	Cook	Bloomington, IN	https://www.linkedin.com/jobs/view/business-	Bloomington	United States	Mid	Onsite	Overview\nThe Business Systems	Business Analysis, Technical	Bloomington	(39.1670396,	39.167040	-86.534288	Business Syster

1	Analyst `1	Medical		sy...			senior		Analyst 1 perfo...	Writing, Software...		-86.5342881)			
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Senior VAT a T
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Business I Reporting
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	Laughlin AFB	(29.3614054, -100.778572)	29.361405	-100.778572	Lead Senio
5	Business Analyst	American National	Springfield, MO	https://www.linkedin.com/jobs/view/business-an...	Spokane	United States	Associate	Onsite	Are you a Business Analyst with a proven abili...	Business Analysis, Problem Solving, Root Cause...	Springfield	(37.2081729, -93.2922715)	37.208173	-93.292271	Busine
6	GIS Analyst	Associated Electric Cooperative Inc.	Springfield, MO	https://www.linkedin.com/jobs/view/gis-analyst...	Spokane	United States	Associate	Hybrid	Are you passionate about the power of geograph...	GIS, ArcGIS, ArcGIS Pro, ArcGIS Hub, ArcGIS Po...	Springfield	(37.2081729, -93.2922715)	37.208173	-93.292271	G
7	Sr Business Systems Analyst	O'Reilly Auto Parts	Springfield, MO	https://www.linkedin.com/jobs/view/sr-business...	Spokane	United States	Mid senior	Onsite	O'Reilly Auto Parts has a proven track record ...	Tuition Educational Assistance Programs	Springfield	(37.2081729, -93.2922715)	37.208173	-93.292271	Sr Busines
8	Senior Network Analyst - DDI	Jobs for Humanity	Springfield, MO	https://www.linkedin.com/jobs/view/senior-netw...	Spokane	United States	Mid senior	Onsite	Company Description\nJobs for Humanity is part...	Information Technology, Network Solutions, DDI...	Springfield	(37.2081729, -93.2922715)	37.208173	-93.292271	Senior Netwo
9	Sr Business	O'Reilly					Mid		Compensation Pay	Business Analysis,					

- After doing pre-processing of text, here we collate the clean tokens.
  - We derive POS tags for words in job description, then finally after cleaning POS tags we have the clean tokens.
- Some stopwords that are present in job description are skipped.

```
[ ] df_master["clean_token"] = [
        [token for token in tokens if len(token) > 1 and token not in ["company", "description", "title", "job", "skills"]]
        for tokens in df_master["clean_token"]
    ]

    df_master = get_count_of_tokens(df_master)

    df_master.head()
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	city	latitude_longitude	latitude	longitude	normalized_job_title
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Market Research Insights Analyst
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Business Systems Analyst 1
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Senior VAT and Indirect Tax Analyst
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	Bloomington	(39.1670396, -86.5342881)	39.167040	-86.534288	Business Intelligence Reporting Analyst 2
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	Laughlin AFB	(29.3614054, -100.778572)	29.361405	-100.778572	Lead Senior Business Analyst

```
[ ] df_master["clean_job_desc"] = [" ".join(x) for x in df_master["clean_token"]]
    df_master.head(5)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	...	latitude_longitude	latitude	longitude	normalized_job_title	job_s
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	...	(39.1670396, -86.5342881)	39.167040	-86.534288	Market Research Insights Analyst	data researc
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	...	(39.1670396, -86.5342881)	39.167040	-86.534288	Business Systems Analyst 1	b techn
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	...	(39.1670396, -86.5342881)	39.167040	-86.534288	Senior VAT and Indirect Tax Analyst	ac vat/g
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	...	(39.1670396, -86.5342881)	39.167040	-86.534288	Business Intelligence Reporting Analyst 2	sap sql
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	...	(29.3614054, -100.778572)	29.361405	-100.778572	Lead Senior Business Analyst	inform r

5 rows × 21 columns

- As last part of text-processing, lemmatization is done.
- This gives us our final job description lemmatized feature.

- Some extra stop words are added that are content-specific.

```
wnl = WordNetLemmatizer()
patterns = "[^a-zA-Z \n\.]"

stopwords_eng = stopwords.words("english")
stopwords_eng.extend(["race", "ethnicity", "religion", "color", "sex", "age",  "national", "origin", "genetic", "information", "sexual",
                      "orientation", "disability", "gender", "identity", "week", "per", "please", "offer", "part time", "example", "compensation",
                      "monday", "tuesday", "wednesday", "thursday", "friday",
                     "saturday", "sunday", "pm", "am"])

def lemmatize_sentence(text):
    text = re.sub(patterns, " ", text)
    tokens = []

    for token in text.split():
        if token and token not in stopwords_eng:
            token = token.strip()
            token = wnl.lemmatize(token)

            tokens.append(token)

    return " ".join(tokens)
```

```
print("Before lemmatization:\n", df_master["clean_job_desc"].iloc[555])
print("\nAfter lemmatization:\n", lemmatize_sentence(df_master["clean_job_desc"].iloc[555]))
```

```
Before lemmatization:
 data analysis data visualization data reconciliation ms excel data discrepancy identification cms fmis tableau dashboard power point access sql odbc service now business system analyst position hybrid location bost

After lemmatization:
 data analysis data visualization data reconciliation m excel data discrepancy identification cm fmis tableau dashboard power point access sql odbc service business system analyst position hybrid location boston dur
```

```
df_master["job_desc_lem"] = df_master["clean_job_desc"].apply(lemmatize_sentence)
df_master.tail(5)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	...	latitude	longitude	normalized_job_title	job_skills_summ
28735	Lead Data Engineer / Gaming space / onsite	Motion Recruitment Partners LLC	Santa Monica, CA	https://www.linkedin.com/jobs/view/lead-data-e...	Thousand Oaks	United States	Mid senior	Onsite	Dice is the leading career destination for tec...	Data Engineering, Data Analytics, Machine Lear...	...	34.019470	-118.491227	Lead Data Engineer Gaming space onsite	data engineering, analytics, machi
28738	Data Engineer	Whitbread	Dunstable, England, United Kingdom	https://uk.linkedin.com/jobs/view/data-enginee...	Milton Keynes	United Kingdom	Mid senior	Onsite	Data Engineer, Full-Time, Permanent, Dunstable...	Data Engineering, Data Pipelines, CI/CD, MLOps...	...	51.886132	-0.520934	Data Engineer	data engineering, pipelines, ci/c
28742	Installation Supervisor (Data Cables / Interna...	Ernest Gordon Recruitment	Northampton, England, United Kingdom	https://uk.linkedin.com/jobs/view/installation...	Milton Keynes	United Kingdom	Mid senior	Onsite	40,000 - 45,000 + Company Van + (47k - 52k) OT...	Installation, Data Cables, Telecommunications,...	...	52.237885	-0.896364	Installation Supervisor	installation, data cal telecommunic
28743	Rewards Data / HR Analyst	Latcom Ltd	Milton Keynes, England, United Kingdom	https://uk.linkedin.com/jobs/view/rewards-data...	Milton Keynes	United Kingdom	Mid senior	Onsite	Rewards Data / HR Analyst, required to work in...	Microsoft Excel, Microsoft Word, Microsoft Pow...	...	52.040650	-0.759409	Rewards Data HR Analyst	microsoft e microsoft v micros
28744	Installation Supervisor Data Cables / Internat...	Ernest Gordon Recruitment	Northampton, England, United Kingdom	https://uk.linkedin.com/jobs/view/installation...	Milton Keynes	United Kingdom	Mid senior	Onsite	Installation Supervisor (Data Cables / Interna...	Installation Supervisor, Data Cables, Telecomm...	...	52.237885	-0.896364	Installation Supervisor Data Cables Internati...	installation superv data cables,

5 rows × 22 columns

```
df_master["token_number_after_lem"] = [len(word.split()) for word in df_master["job_desc_lem"]]
df_master.head()
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_summary	job_skills	...	longitude	normalized_job_title	job_skills_summary	POS	POS
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Company Description\nAre you a high-performer ...	Data analysis, Market research, Survey develop...	...	-86.534288	Market Research Insights Analyst	data analysis, market research, survey deve...	[(data, NNS), (analysis, NN), (,, ,), (market,...	[(dat (, N (n
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Overview\nThe Business Systems Analyst 1 perfo...	Business Analysis, Technical Writing, Software...	...	-86.534288	Business Systems Analyst 1	business analysis, technical writing, sof...	[(business, NN), (analysis, NN), (,, ,), (tech...	[(b (, N
2	Senior VAT and Indirect Tax Analyst	Epic	Bloomington, IN	https://www.linkedin.com/jobs/view/senior-vat-...	Bloomington	United States	Mid senior	Onsite	We're looking for an experienced tax professio...	Accounting, Finance, VAT/GST tax regimes, US a...	...	-86.534288	Senior VAT and Indirect Tax Analyst	accounting, finance, vat/gst tax regimes, ...	[(accounting, NN), (,, ,), (finance, NN), (,, ...	[(acc N (N
3	Business Intelligence Reporting Analyst 2	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-in...	Bloomington	United States	Mid senior	Hybrid	Overview\nThe Business Intelligence Analyst 2 ...	SAP Business Objects, SQL, Qlik, Data Modeling...	...	-86.534288	Business Intelligence Reporting Analyst 2	sap business objects, sql, qlik, data mod...	[(sap, NN), (business, NN), (objects, NNS), (,...	[(s (b N
4	Lead Senior Business Analyst	Nashville Toyota North	Laughlin AFB, TX	https://www.linkedin.com/jobs/view/lead-senior...	Del Rio	United States	Mid senior	Hybrid	R2C, Inc. is a rapidly growing, SDVOSB headqua...	Information technology, Microsoft Office, Data...	...	-100.778572	Lead Senior Business Analyst	information technology, microsoft office, ...	[(information, NN), (technology, NN), (,, ,), ...	[(infc (tec NN)

5 rows × 23 columns

```
df_master.to_csv('/content/drive/MyDrive/418/text_processed.csv', index=False)
```

This is our final processed data which will now be used for modelling.

```
df_master = pd.read_csv('/content/drive/MyDrive/418/text_processed.csv')
```

```
df_master.columns
```

```
Index(['job_title', 'company', 'job_location', 'job_link', 'search_city',
       'search_country', 'job level', 'job_type', 'job_summary', 'job_skills',
       'city', 'latitude_longitude', 'latitude', 'longitude',
       'normalized_job_title', 'job_skills_summary', 'POS', 'POS_clean',
       'clean_token', 'token_number', 'clean_job_desc', 'job_desc_lem',
       'token_number_after_lem'],
      dtype='object')
```

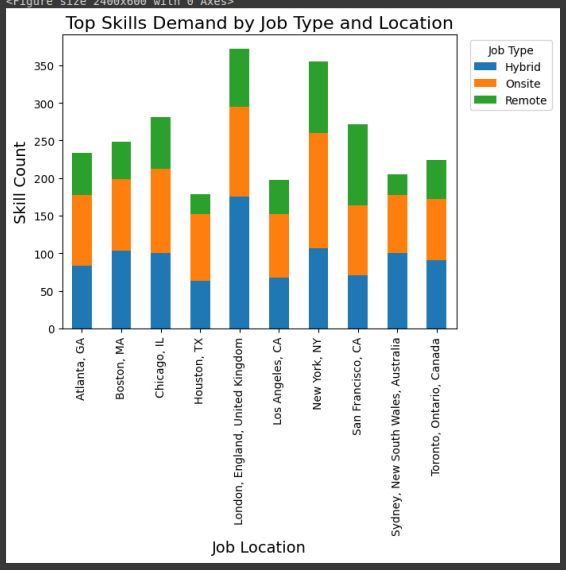
Visualization 3: Shahbaz Syed

- The chart presents the demand for various job skills across key global cities, categorizing roles into Hybrid, Onsite, and Remote.
- It reveals a notable preference for remote jobs in cities like New York and San Francisco, while onsite work remains prevalent in Chicago and London.

- This visualization serves as a strategic guide for job seekers and companies to understand and adapt to evolving employment trends.*italicized text*

```
[ ] top_locations = df_master['job_location'].value_counts().head(10).index

    pivot_data = pd.pivot_table(df_master[df_master['job_location'].isin(top_locations)],
                                index='job_location',
                                columns='job_type',
                                values='token_number_after_lem',
                                aggfunc='count',
                                fill_value=0)


    pivot_data = pivot_data.reset_index().sort_values(by='job_location')

    plt.figure(figsize=(24, 6))
    pivot_data.set_index('job_location')[sorted(pivot_data.columns[1:])].plot(kind='bar', stacked=True)
    plt.title('Top Skills Demand by Job Type and Location', fontsize=16)
    plt.xlabel('Job Location', fontsize=14)
    plt.ylabel('Skill Count', fontsize=14)
    plt.legend(title='Job Type', bbox_to_anchor=(1.02, 1), loc='upper left')
    plt.xticks(rotation=90)
    plt.show()
```

```
<Figure size 2400x600 with 0 Axes>
```



Visualization 4: Shahbaz Syed

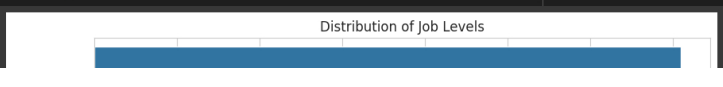
- The word cloud displayed visualizes the frequency of various skills demanded in the top five job categories.
- Prominent terms like 'Software Development,' 'AWS,' and 'Data Engineering' stand out, suggesting their critical importance in the job market.
- This offers a quick and intuitive way to understand the skill sets that are currently in high demand.

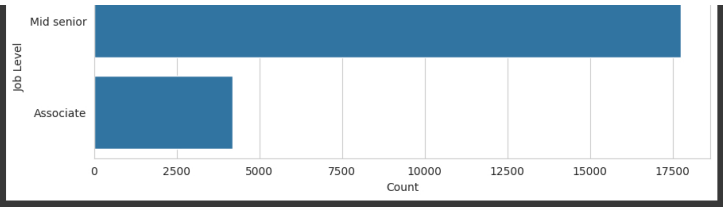
```
[ ] from wordcloud import WordCloud

    top_job_titles = df_master['job_title'].value_counts().index[:5]
    df_top_jobs = df_master[df_master['job_title'].isin(top_job_titles)]

    skills_string = " ".join(skill for skill in df_top_jobs['job_skills'])

    wordcloud = WordCloud(background_color='white').generate(skills_string)

    plt.figure(figsize=(10, 7))
    plt.imshow(wordcloud, interpolation='bilinear')
    plt.title('Word Cloud for Job Skills for top 5 type of jobs')
    plt.axis('off')
    plt.show()
```

Visualization 5: VVS Phani

- The bar chart illustrates the distribution of job levels, comparing the prevalence of 'Associate' versus 'Mid Senior' level positions.
- The data shows a significantly higher count of 'Mid Senior' level jobs, highlighting a potential market trend favoring more experienced professionals.
- This insight could be critical for both job seekers and employers in understanding the current employment landscape.

```
[ ] sns.set_style("whitegrid")
    plt.figure(figsize=(10, 3))
    sns.countplot(y='job level', data=df_master, order = df_master['job level'].value_counts().index)
    plt.title('Distribution of Job Levels')
    plt.xlabel('Count')
    plt.ylabel('Job Level')
    plt.show()
```

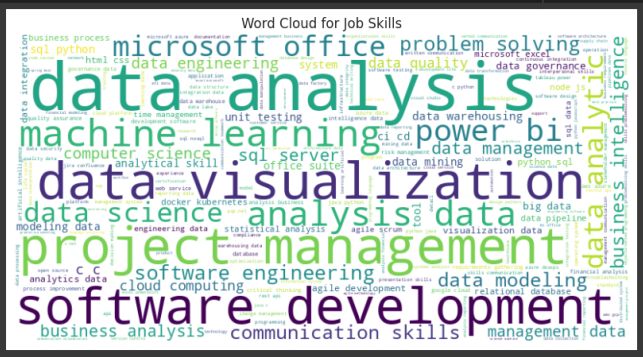




Visualization 6: VVS Phani

- The word cloud depicted focuses on key skills relevant to the job market, with terms like 'data analysis,' 'machine learning,' 'project management,' and 'software development' being especially prominent.
- This suggests a high demand for these skills across various industries in general.
- The graphic serves as a visual guide for individuals looking to refine their expertise to align with market needs.

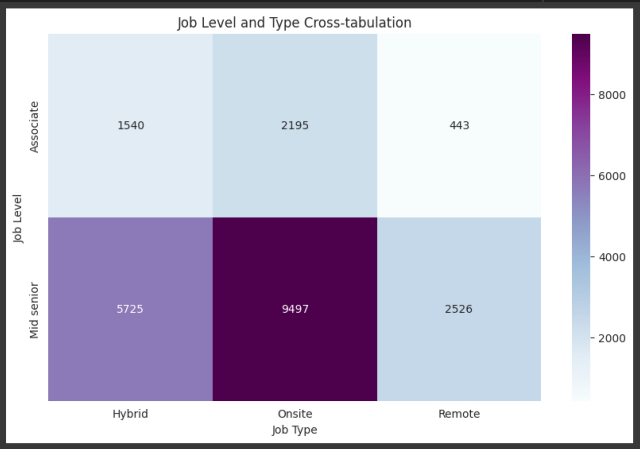
```
[ ] skills_series = df_master['job_skills'].dropna().apply(lambda x: ' '.join(x.lower().split(',')))
    all_skills = ' '.join(skills_series)
    wordcloud = WordCloud(width=800, height=400, background_color ='white').generate(all_skills)

    plt.figure(figsize=(10, 7))
    plt.imshow(wordcloud, interpolation='bilinear')
    plt.axis('off')
    plt.title('Word Cloud for Job Skills')
    plt.show()
```



Visualization 7: VVS Phani

- The heatmap visualizes a cross-tabulation of job levels against job types. - Mid-senior level roles dominate, especially in the onsite category, indicating a mature job market.
- Associate roles are fewer in comparison, with hybrid roles outnumbering remote opportunities at this level.
- This data could inform job seekers about the most prevalent job types at different career stages.

```
[ ] plt.figure(figsize=(10, 6))
    job_level_type_cross = pd.crosstab(df_master['job level'], df_master['job_type'])
    sns.heatmap(job_level_type_cross, annot=True, fmt="d", cmap="BuPu")
    plt.title('Job Level and Type Cross-tabulation')
    plt.xlabel('Job Type')
    plt.ylabel('Job Level')
    plt.show()
```



[ ]

[ ]

[ ]

Dropping features that are not required now as they are redundant and other feature carry the inherent information they provide.

[ ]

[ ]

```
[ ] df_master.drop(['latitude_longitude', 'POS', 'POS_clean', 'clean_token', 'token_number', 'clean_job_desc', 'job_summary', 'latitude', 'longitude'],  axis=1, inplace=True)
```

```
[ ] df_master.head(2)
```

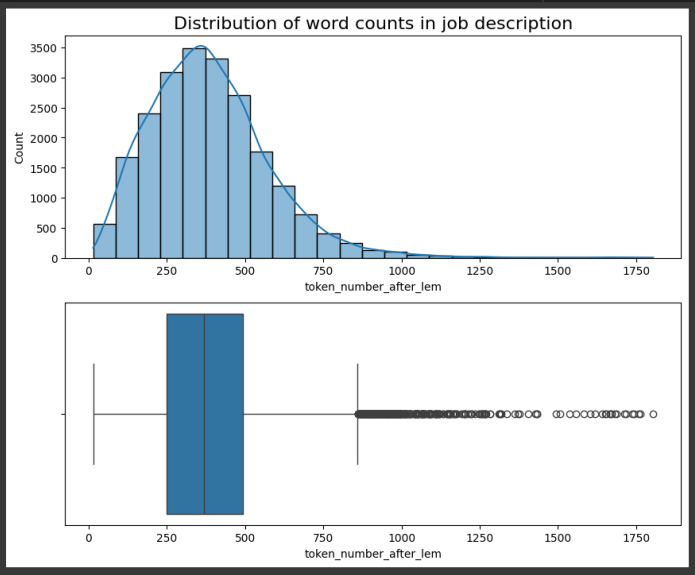
	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_skills	city	normalized_job_title	job_skills_summary	job_desc_lem	token_number_after_l
0	Market Research & Insights Analyst	Indiana University Foundation	Bloomington, IN	https://www.linkedin.com/jobs/view/market-rese...	Bloomington	United States	Mid senior	Onsite	Data analysis, Market research, Survey	Bloomington	Market Research Insights Analyst	data analysis, market research, survey deve...	data analysis market research survey develope	

									develop...					
1	Business Systems Analyst `1	Cook Medical	Bloomington, IN	https://www.linkedin.com/jobs/view/business-sy...	Bloomington	United States	Mid senior	Onsite	Business Analysis, Technical Writing, Software...	Bloomington	Business Systems Analyst 1	business analysis, technical writing, sof...	business analysis technical writing software t...	

This gives us the spread of token across the data.

- Though outliers are present (Jobs with more than 800 tokens in job summary), we are not removing them or truncating as they can contain rich-information that can help the model.
- This may lead to sparsity but we are not concerned with that at this point in time.

```
[ ] from scipy.stats import normaltest

    df_master["token_number_after_lem"].describe()
    fig, axes = plt.subplots(nrows=2, ncols=1, figsize=(10, 8))

    histplot = sns.histplot(
        data=df_master,
        x="token_number_after_lem",
        bins=25,
        kde=True,
        ax=axes[0]);
    histplot.set_title("Distribution of word counts in job description",  fontsize=16);

    boxplot = sns.boxplot(
        data=df_master,
        x="token_number_after_lem",
        orient="h",
        width=0.9,
        ax=axes[1]);
```




```
[ ]
```

```
[ ] from collections import Counter, defaultdict

    df_master[df_master["token_number_after_lem"] > 800]['job_desc_lem'].count()
```

```
630
```

```
[ ] # Not removing the jobs as outliers with more token. May contain important information needed.
```

```
[ ] df_master["normalized_job_title"][5]
```

```
'Business Analyst'
```

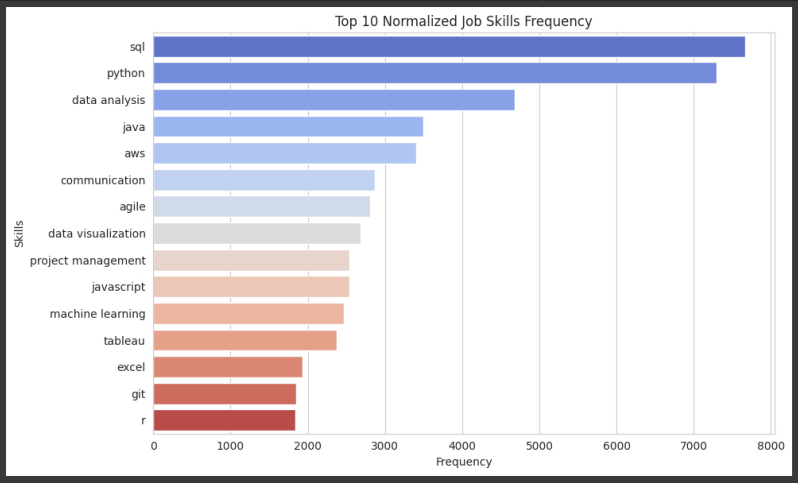
```
[ ] def normalize_skills(skill_string):

        return [skill.strip().lower() for skill in skill_string.split(',') if skill]

    df_master['normalized_job_skills'] = df_master['job_skills'].apply(lambda x: normalize_skills(x))

    def top_n_skills(skill_lists, n=10):
        aggregated_skills = Counter([skill for sublist in skill_lists for skill in sublist if skill])
        return aggregated_skills.most_common(n)

    skill_counts_per_job_title = df_master.groupby('normalized_job_title')['normalized_job_skills'].agg(lambda x: top_n_skills(x, n=10)).reset_index(name='top_skills')
    top_20_titles = df_master['normalized_job_title'].value_counts().head(20).index.tolist()

    for title in top_20_titles:
        top_skills = skill_counts_per_job_title.loc[skill_counts_per_job_title['normalized_job_title'] == title, 'top_skills'].iloc[0]
        print(f"Top 10 skills for {title}: {top_skills}")
```

```
Top 10 skills for Senior Software Engineer: [('python', 796), ('java', 725), ('aws', 690), ('sql', 577), ('javascript', 510), ('agile', 489), ('docker', 402), ('go', 370), ('kubernetes', 369), ('typescript', 351)]
Top 10 skills for Software Engineer: [('python', 357), ('java', 282), ('javascript', 254), ('aws', 235), ('software engineering', 222), ('git', 210), ('c++', 208), ('sql', 203), ('c#', 194), ('react', 176)]
Top 10 skills for Business Analyst: [('business analysis', 296), ('project management', 197), ('data analysis', 164), ('communication', 129), ('requirements gathering', 108), ('agile', 103), ('sql', 101), ('excel',
Top 10 skills for Senior Data Engineer: [('python', 427), ('sql', 364), ('data engineering', 247), ('aws', 195), ('snowflake', 159), ('spark', 153), ('data modeling', 152), ('etl', 140), ('data warehousing', 137),
Top 10 skills for Data Engineer: [('python', 283), ('sql', 279), ('data engineering', 190), ('aws', 139), ('etl', 122), ('data warehousing', 118), ('data modeling', 104), ('azure', 91), ('data pipelines', 89), ('spa
Top 10 skills for Data Scientist: [('python', 345), ('machine learning', 291), ('data science', 260), ('sql', 230), ('r', 206), ('data visualization', 147), ('data analysis', 135), ('statistics', 114), ('data mining
Top 10 skills for Data Analyst: [('data analysis', 266), ('sql', 257), ('data visualization', 178), ('tableau', 144), ('python', 129), ('power bi', 110), ('excel', 108), ('data mining', 78), ('r', 74), ('communicati
Top 10 skills for Senior Financial Analyst: [('financial analysis', 214), ('budgeting', 181), ('forecasting', 173), ('accounting', 162), ('financial modeling', 145), ('excel', 140), ('data analysis', 124), ('financi
Top 10 skills for Senior Data Scientist: [('python', 303), ('machine learning', 284), ('sql', 220), ('data science', 197), ('r', 166), ('data visualization', 109), ('statistics', 100), ('data analysis', 97), ('aws',
Top 10 skills for Senior Data Analyst: [('sql', 251), ('data analysis', 193), ('python', 181), ('tableau', 170), ('data visualization', 161), ('power bi', 117), ('r', 108), ('data analytics', 85), ('excel', 75), ('t
Top 10 skills for Software Developer: [('c#', 130), ('javascript', 115), ('sql', 89), ('software development', 81), ('java', 81), ('python', 75), ('git', 70), ('css', 63), ('.net', 62), ('agile', 56)]
Top 10 skills for Senior Analyst: [('data analysis', 95), ('sql', 81), ('excel', 79), ('communication', 74), ('project management', 63), ('tableau', 61), ('data visualization', 47), ('problem solving', 43), ('pythor
Top 10 skills for Business Systems Analyst: [('sql', 96), ('project management', 83), ('business analysis', 75), ('communication', 65), ('data analysis', 59), ('agile', 51), ('business systems analysis', 46), ('prol
Top 10 skills for Lead Software Engineer: [('java', 161), ('aws', 157), ('python', 139), ('sql', 134), ('javascript', 105), ('cloud computing', 105), ('agile', 96), ('go', 94), ('typescript', 93), ('microservices',
Top 10 skills for Senior Software Developer: [('javascript', 92), ('c#', 87), ('sql', 66), ('aws', 58), ('software development', 56), ('git', 54), ('python', 51), ('agile', 51), ('java', 50), ('angular', 44)]
Top 10 skills for Business Intelligence Analyst: [('sql', 101), ('business intelligence', 89), ('data visualization', 86), ('data analysis', 81), ('tableau', 70), ('power bi', 62), ('python', 45), ('data modeling',
Top 10 skills for Staff Software Engineer: [('python', 51), ('java', 48), ('aws', 40), ('javascript', 34), ('react', 31), ('kubernetes', 29), ('software engineering', 28), ('sql', 27), ('agile', 22), ('c++', 21)]
Top 10 skills for Embedded Software Engineer: [('c++', 53), ('python', 38), ('c', 37), ('embedded systems', 29), ('linux', 25), ('i2c', 22), ('spi', 22), ('git', 21), ('embedded software development', 19), ('c/c++',
Top 10 skills for Senior Business Analyst: [('business analysis', 67), ('project management', 42), ('data analysis', 33), ('sql', 26), ('communication', 26), ('requirements gathering', 22), ('stakeholder management'
Top 10 skills for Senior Embedded Software Engineer: [('c++', 46), ('python', 35), ('c', 32), ('git', 24), ('linux', 23), ('embedded linux', 22), ('rtos', 21), ('embedded systems', 20), ('spi', 20), ('c programming'
```

Visualization 8: Usha

- The bar chart ranks the top 10 normalized job skills in frequency, with 'SQL' and 'Python' leading the chart, indicative of their high demand in the tech industry.
- Skills in 'data analysis' and 'java' are also prevalent, while 'communication' skills are emphasized as essential.
- This information is crucial for job seekers aiming to prioritize their learning and development focus areas.

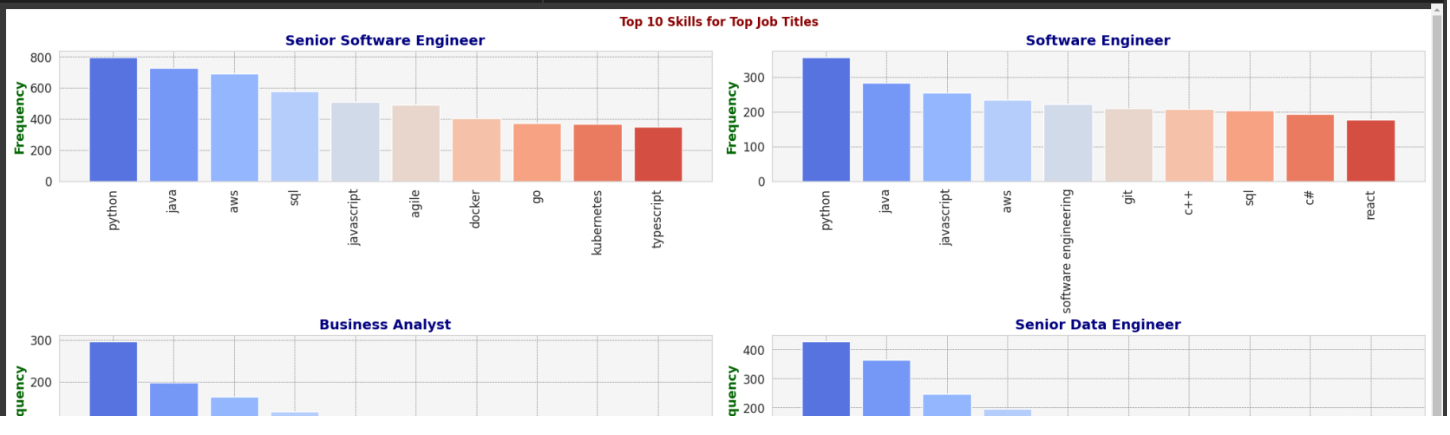
```
[ ] sns.set_style("whitegrid")
    all_skills_dict = {}
    for skills_list in df_master['normalized_job_skills']:
        for skill in skills_list:
            if skill in all_skills_dict:
                all_skills_dict[skill] += 1
            else:
                all_skills_dict[skill] = 1


    top_skills_dict = dict(sorted(all_skills_dict.items(), key=lambda item: item[1], reverse=True)[:15])


    top_skills_df = pd.DataFrame(list(top_skills_dict.items()), columns=['Skill', 'Frequency'])

    plt.figure(figsize=(10, 6))
    sns.barplot(x='Frequency', y='Skill', data=top_skills_df, palette='coolwarm')
    plt.title('Top 10 Normalized Job Skills Frequency')
    plt.xlabel('Frequency')
    plt.ylabel('Skills')
    plt.tight_layout()

    plt.show()
```

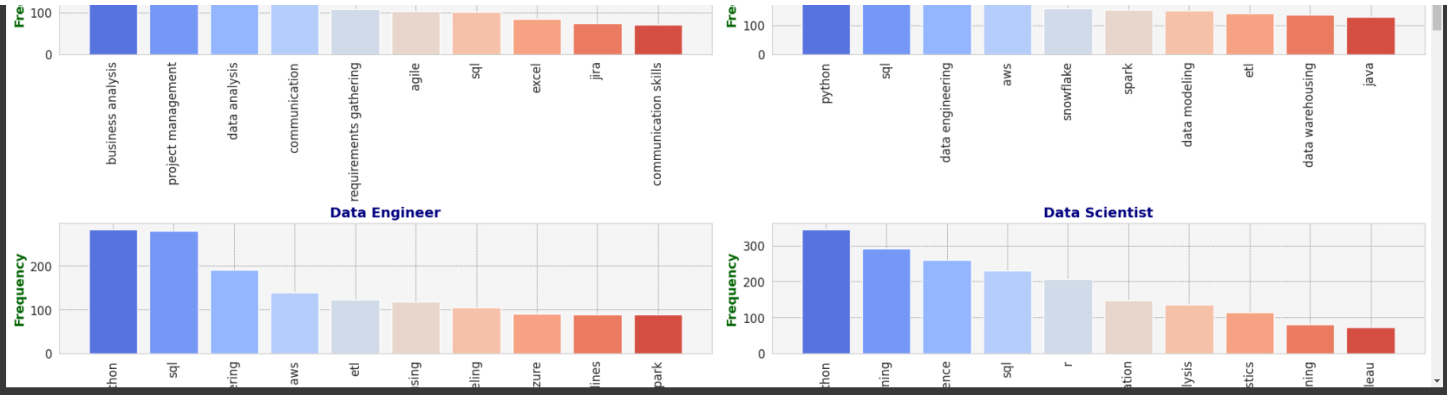


Visualization 9: Saurav Joshi

- After having the final data ready, this visualization helps us know the most common skills required in jobs.
- This can directly help a candidate to align themselves with these skills based on the job they are looking for.
- Also it can be seen as learning Python and SQL has the best advantage as it is present across job titles.

```
[ ] sns.set_style("whitegrid")

    ncols = 2
    num_titles_to_plot = 10
    nrows = num_titles_to_plot // ncols + (num_titles_to_plot % ncols > 0)
    fig, axs = plt.subplots(nrows=nrows, ncols=ncols, figsize=(20, 4 * nrows), constrained_layout=True)


    palette = sns.color_palette("coolwarm", n_colors=10)
    axs = axs.flatten()

    for i, title in enumerate(top_20_titles[:num_titles_to_plot]):

        top_skills = skill_counts_per_job_title.loc[skill_counts_per_job_title['normalized_job_title'] == title, 'top_skills'].iloc[0]
        skills, counts = zip(*top_skills)


        axs[i].bar(skills, counts, color=palette)
        axs[i].set_title(title, fontsize=14, fontweight='bold', color='navy')
        axs[i].tick_params(axis='x', rotation=90, labelsize=12)  # Increase rotation to 90 degrees
        axs[i].tick_params(axis='y', labelsize=12)
        axs[i].set_ylabel('Frequency', fontsize=13, fontweight='bold', color='darkgreen')


        axs[i].grid(True, which='major', linestyle='--', linewidth='0.5', color='grey')
        axs[i].set_facecolor('whitesmoke')

    for i in range(len(top_20_titles[:num_titles_to_plot]), len(axs)):
        axs[i].axis('off')

    plt.suptitle('Top 10 Skills for Top Job Titles', fontsize=12, fontweight='bold', color='darkred')
    plt.show()
```





Modelling

- Use **CountVectorizer** and **TfidfVectorizer** to convert text (processed job summary) into vectors.
- Using n-gram range from 1-2 for CountVectorizer as words like "machine learning" are relatively rich in information than machine and learning independently.
- Avoiding words that are over 95% and less than 5 in frequency.
- Getting cosine similarity for a sample resume and the vectors generated.

> Saurav Joshi

```
[ ] from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer
    from sklearn.metrics.pairwise import cosine_similarity
    stop_words = set(stopwords.words('english'))
    lemmatizer = WordNetLemmatizer()

    def preprocess_text(text):
        text = text.lower()
        text = re.sub(r'[^\w\s]', '', text)
        tokens = nltk.word_tokenize(text)
        tokens = [lemmatizer.lemmatize(token) for token in tokens if token not in stop_words]
        processed_text = ' '.join(tokens)
        return processed_text

    # Baseline model setup
    count_vect = CountVectorizer(ngram_range=(1,2), min_df=5, max_df=0.95)
    count_job_desc = count_vect.fit_transform(df_master["job_desc_lem"])

    # TF-IDF model setup
    tfidf_vect = TfidfVectorizer(min_df=5, max_df=0.95)
    tfidf_job_desc = tfidf_vect.fit_transform(df_master["job_desc_lem"])
```

> A common function to process similarities based on tfidf or countVec
>
> - It is interesting to note that CountVectorizer's top 5 jobs possess more similarity with the resume than TfidfVectorizer.
>   - However, this is because of the way **TfidfVectorizer** calculates the numerical value for a given vector. It adjusts for the frequency of the word in the corpus of documents. This means that common words across all documents are given less weight, and unique words are given more weight.
> - The **CountVectorizer** model may be overemphasizing the importance of frequent terms, which can artificially inflate the similarity score, even if those terms aren't particularly meaningful.
> - Thus, a higher cosine similarity score does not always mean a better match in terms of relevancy.

```
[ ] def jobs_to_resume(raw_resume_text, model_type='tfidf'):
        resume_text = preprocess_text(raw_resume_text)

        if model_type == 'tfidf':
            resume_vector = tfidf_vect.transform([resume_text])
            job_desc_vector = tfidf_job_desc
        else:
            resume_vector = count_vect.transform([resume_text])
            job_desc_vector = count_job_desc

        cosine_similarities = cosine_similarity(resume_vector, job_desc_vector).flatten()
        top_5_job_indices = cosine_similarities.argsort()[-5:][::-1]

        top_5_jobs = df_master.iloc[top_5_job_indices]
        job_indices = top_5_jobs.index

        return top_5_jobs, job_indices, cosine_similarities[top_5_job_indices], resume_vector

    # This is for now. This shall be updated to a resume parser.
    raw_parsed_resume_text = "Saul Joshi 347-466-8549 | sjoshi50@uic.edu | linkedin.com/in/sauravjoshi27 | github.com/sauravjoshi | sauravjoshi.dev Versatile Software Engineer: Transforming Ideas into Reality with 3+ \

    recommended_jobs_tfidf, job_indices_tfidf, scores_tfidf, resume_vector_tfidf = jobs_to_resume(raw_parsed_resume_text, 'tfidf')

    recommended_jobs_count, job_indices_count, scores_count,resume_vector_count = jobs_to_resume(raw_parsed_resume_text, 'count')

    print("TF-IDF Model Recommendations:")
    for job_idx, score in zip(job_indices_tfidf, scores_tfidf):
        print(f"Job Index: {job_idx}, Score: {score:.4f}")
        print(f"Job Description: {df_master.loc[job_idx, 'job_desc_lem']}")
        print("-----")

    print("\nCount Vectorizer Model Recommendations:")
    for job_idx, score in zip(job_indices_count, scores_count):
        print(f"Job Index: {job_idx}, Score: {score:.4f}")
        print(f"Job Description: {df_master.loc[job_idx, 'job_desc_lem']}")
        print("-----")
```

```
TF-IDF Model Recommendations:
Job Index: 19972, Score: 0.2335
Job Description: ai data science team leadership nlp computer vision ml python pytorch tensorflow currently partnered exciting well funded fintech start greater san diego area looking expand data science team respor
-----
Job Index: 18653, Score: 0.2250
Job Description: data science machine learning artificial intelligence natural language processing audio signal processing video signal processing speech processing large language model llm python aws cloud service
-----
Job Index: 19906, Score: 0.2133
Job Description: data science machine learning natural language processing speech processing audio processing python py torch tensor flow tiny ml panda num py spark dask ray aws azure gcloud linux ssh department bs
-----
Job Index: 18400, Score: 0.2090
Job Description: nlp machine learning python tensorflow py torch scikit learn num py panda matplotlib seaborn jupyter notebook google colab bert lla predictive modeling transfer learning big data deep learning model
-----
Job Index: 19298, Score: 0.2070
Job Description: python programming tensor flow kera py torch panda numpy scikit learn nltk scipy transformer based deep learning nlp model llm prompt engineering finetuning llm training llm model rag based busines
-----

Count Vectorizer Model Recommendations:
Job Index: 19904, Score: 0.3167
```

```
Job Description: programming data science engineering scalable application web application visualization interface web framework apis database visualization framework backend language python java script html cs angu
-----
Job Index: 19906, Score: 0.3049
Job Description: data science machine learning natural language processing speech processing audio processing python py torch tensor flow tiny ml panda num py spark dask ray aws azure gcloud linux ssh department bsc
-----
Job Index: 17184, Score: 0.3033
Job Description: full stack development web development software engineering aws api development unit testing integration testing endto end testing java script type script html cs react angular vue j oauth jwt git e
-----
Job Index: 12104, Score: 0.2945
Job Description: software engineering research development embedded system backend development database architecture data warehouse strategy data governance data security data modeling data mart data ingestion etl s
-----
Job Index: 12866, Score: 0.2870
Job Description: angular java script html typescript cs .js web development software development machine learning user interface design data visualization data synchronization unit testing diamond kinetics diamond k
-----
```

```
[ ] recommended_jobs_count.head(3)
```

	job_title	company	job_location	job_link	search_city	search_country	job level	job_type	job_skills	city	normalized_job_title	job_skills_summary	job_desc_lem	token_number_after_l
19904	Data Scientist, Senior Analyst	University of Chicago	Chicago, IL	https://www.linkedin.com/jobs/view/data-scient...	Chicago	United States	Mid senior	Onsite	Programming, Data science, Engineering, Scalab...	Chicago	Data Scientist	programming, data science, engineering, sc...	programming data science engineering scalable ...	7
19906	Sr. Data Scientist	University of Chicago	Chicago, IL	https://www.linkedin.com/jobs/view/sr-data-sci...	Chicago	United States	Mid senior	Onsite	Data science, Machine learning, Natural langua...	Chicago	Senior Data Scientist	data science, machine learning, natural lan...	data science machine learning natural language...	7
17184	Software Developer	Project Canary	Denver, CO	https://www.linkedin.com/jobs/view/software-de...	Boulder	United States	Mid senior	Onsite	Full Stack Development, Web Development, Softw...	Denver	Software Developer	full stack development, web development, ...	full stack development web development softwar...	3

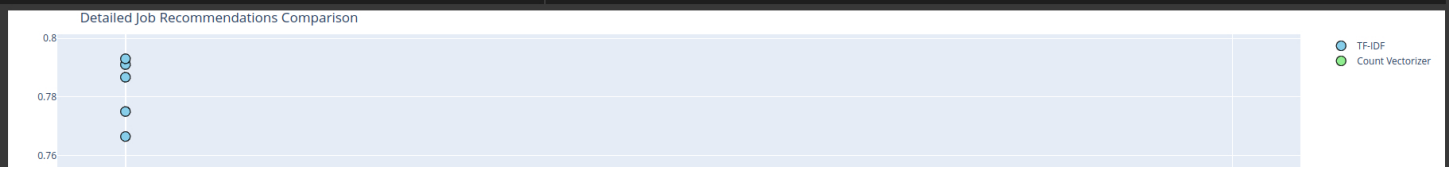
Next we employ a KNN-based recommender system to match job descriptions with a candidate's resume.

- Unlike relying solely on term frequency metrics from `CountVectorizer` or `TfidfVectorizer`, our KNN approach captures the nuanced similarities within the feature space.
- This method enhances the recommendation quality by considering a wider context and providing more personalized job matches.
- It proves advantageous as it factors in the multidimensional relationship between data points, offering a sophisticated alternative to simple similarity scoring.

```
[ ] import pandas as pd
    import matplotlib.pyplot as plt
    from sklearn.neighbors import NearestNeighbors

    def get_recommendations(model, job_desc_matrix, resume_vector, n_neighbors=5):

        model.fit(job_desc_matrix)

        distances, indices = model.kneighbors(resume_vector, n_neighbors=n_neighbors)

        recommendations = []
        for dist, idx in zip(distances[0], indices[0]):
            job_info = df_master.iloc[idx].to_dict()
            job_info['Match Distance'] = dist
            recommendations.append(job_info)
        return pd.DataFrame(recommendations)

    knn = NearestNeighbors(n_neighbors=5, metric='cosine')

    count_recommendations = get_recommendations(knn, count_job_desc, resume_vector_count, n_neighbors=5)
    tfidf_recommendations = get_recommendations(knn, tfidf_job_desc, resume_vector_tfidf, n_neighbors=5)
```

- It is intersting to note that the Match distance for CountVectorizer base recommendations is low in comparison with TfidfVectorizer which clearly illustrated the shortcoming of Tfldf punishing resume description keywords occurence across the corpus.
- We thus aim to move towards more contextually rich embedddings word2vec, glove, or use state-of-the-art open source Embedding models or APIs.

```
[ ] import plotly.graph_objects as go


    x_tfidf = [0] * len(tfidf_recommendations['Match Distance'])
    x_count = [1] * len(count_recommendations['Match Distance'])


    fig = go.Figure()

    fig.add_trace(go.Scatter(
        x=x_tfidf,
        y=tfidf_recommendations['Match Distance'],
        mode='markers',
        name='TF-IDF',
        marker=dict(color='skyblue', size=12, line=dict(color='black', width=1)),
        text=tfidf_recommendations['job_title'],
        hoverinfo='text+y'
    ))

    fig.add_trace(go.Scatter(
        x=x_count,
        y=count_recommendations['Match Distance'],
        mode='markers',
        name='Count Vectorizer',
        marker=dict(color='lightgreen', size=12, line=dict(color='black', width=1)),
        text=count_recommendations['job_title'],
        hoverinfo='text+y'
    ))

    fig.update_layout(
        title='Detailed Job Recommendations Comparison',
        xaxis=dict(
            tickmode='array',
            tickvals=[0, 1],
            ticktext=['TF-IDF', 'Count Vectorizer']
        ),
        yaxis_title="Match Distance",
        margin=dict(l=20, r=20, t=30, b=20)
    )

    fig.show()
```



Visualization 10: Saurav Joshi

- Trying to visualize how the recommended jobs are closer to resume in reduced dimensionality space (from original tfidf vector [21926 X 18017]).
- Leverage T-SNE for two-dimensional t-SNE space.
- The cluster of blue dots near the 'X' suggests that the top recommendations are indeed closely aligned with the resume's features.

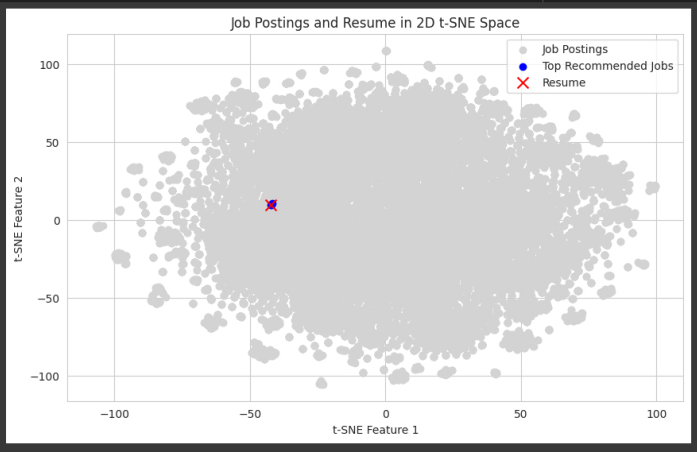
```
[ ] tfidf_job_desc.shape
```

```
(21926, 18017)
```

```
[ ] from sklearn.manifold import TSNE

    # Use t-SNE to reduce the tf-idf vectors to two dimensions
    tsne = TSNE(n_components=2, random_state=42)
    tfidf_reduced_tsne = tsne.fit_transform(tfidf_job_desc.toarray())
```

```
[ ] combined_tfidf = np.vstack((tfidf_job_desc.toarray(), resume_vector_tfidf.toarray()))
    combined_reduced_tsne = tsne.fit_transform(combined_tfidf)

    resume_reduced_tsne = combined_reduced_tsne[-1]
    top_jobs_reduced_tsne = combined_reduced_tsne[job_indices_tfidf]
```

```
[ ] plt.figure(figsize=(10, 6))

    plt.scatter(tfidf_reduced_tsne[:, 0], tfidf_reduced_tsne[:, 1], c='lightgray', label='Job Postings')
    plt.scatter(top_jobs_reduced_tsne[:, 0], top_jobs_reduced_tsne[:, 1], c='blue', label='Top Recommended Jobs')
    plt.scatter(resume_reduced_tsne[0], resume_reduced_tsne[1], c='red', marker='x', s=100, label='Resume')

    plt.xlabel('t-SNE Feature 1')
    plt.ylabel('t-SNE Feature 2')
    plt.title('Job Postings and Resume in 2D t-SNE Space')
    plt.legend()
    plt.show()
```



Measurements

1. Creating 2 ground truth for the resume.
   - Job Titles relevant to the resume
   - Job Skills relevant to the resume
2. Finally looking into the recommended jobs based on both Count and TF-IDF vector to check similarity with the ground truth labels.

```
[ ] # Measuring How good the recommendations are.
    # Using fuzzy matching instead of direct equivalent keyword matching.
    !pip install fuzzywuzzy
```

```
[ ] from fuzzywuzzy import fuzz

    base_job_titles = ['Data Scientist', 'Machine Learning Engineer', 'Software Engineer']
    base_skills = ['Python', 'Machine Learning', 'Deep Learning', 'C++', 'Node.JS', 'JavaScript', 'MongoDB']

    def count_relevant_titles(recommendations, base_titles):
        count = 0
        for title in recommendations['normalized_job_title']:
            if any(fuzz.partial_ratio(title.lower(), ref.lower()) > 80 for ref in base_titles):
                count += 1
        return count

    def count_relevant_skills(recommendations, base_skills):
        count = 0
        for skills in recommendations['normalized_job_skills']:
            individual_skills = skills
            for skill in individual_skills:
                if any(fuzz.partial_ratio(skill.strip().lower(), ref.lower()) > 90 for ref in base_skills):
                    count += 1
                    break
        return count


    relevant_titles_tfidf = count_relevant_titles(tfidf_recommendations, base_job_titles)
    relevant_titles_count = count_relevant_titles(count_recommendations, base_job_titles)

    relevant_skills_tfidf = count_relevant_skills(tfidf_recommendations, base_skills)
    relevant_skills_count = count_relevant_skills(count_recommendations, base_skills)
```

```
print("TF-IDF Recommendations:")
print(f"Relevant Titles: {relevant_titles_tfidf} / {len(tfidf_recommendations)}")
print(f"Relevant Skills: {relevant_skills_tfidf} / {len(tfidf_recommendations)}")

print("\nCount Vectorizer Recommendations:")
print(f"Relevant Titles: {relevant_titles_count} / {len(count_recommendations)}")
print(f"Relevant Skills: {relevant_skills_count} / {len(count_recommendations)}")
```

```
TF-IDF Recommendations:
Relevant Titles: 5 / 5
Relevant Skills: 5 / 5

Count Vectorizer Recommendations:
Relevant Titles: 4 / 5
Relevant Skills: 5 / 5
```

Project Reflection

Challenges Encountered

- **Data Procurement and Processing**: Securing appropriate data, particularly managing and deriving insights from textual content, alongside the complexities of modeling based on this data.

Initial Insights

- **Model Performance**: The existing model is adept at providing job recommendations, with plans to further explore and utilize advanced embedding techniques for future model iterations.

Concrete Results

- **Relevancy of Recommendations**: The model's job recommendations align closely with the baseline resume, showcasing the practical effectiveness of the current system.

Future Hurdles

- **Enhanced Embeddings**: The primary focus is now on incorporating embeddings that capture richer contextual information to refine the recommendation process further.

Project Trajectory

- **On Track**: The project is progressing as planned, aligning with the goals and deliverables outlined during the initial pitch presentation.

Forward Strategy

- **Viability and Advancements**: The positive outcomes justify the project's continuation, with an immediate strategy to adopt state-of-the-art embedding models to improve the system's recommendation capabilities.

Next Steps:

1. We will be building entire application that takes in your resume, stores it in your machine (keeping your sensistive data to you).
2. Using Clustering and KNN interpolated to recommend jobs for top job titles.
3. Moving to advanced embedding techniques.

```
[ ]
```

```
[ ]
```

```
[ ]
```

```
[ ]
```