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Course: BIL570 /BIL470

Real / Fake Job Posting Prediction

In [ ]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import re
import nltk
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
from sklearn.feature_extraction.text import TfidfVectorizer
from nltk.tokenize import word_tokenize, sent_tokenize
from nltk import pos_tag
from nltk.util import ngrams
import spacy
import matplotlib.pyplot as plt
import re
import matplotlib.pyplot as plt
from wordcloud import WordCloud
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import CountVectorizer
```

Loading Dataset

In [ ]:

```
# Loading dataset
data = pd.read_csv('fake_job_postings.csv')
```

Exploratory Data Analysis (EDA)

In [ ]:

```
data.head()
```

Out[ ]:

	job_id	title	location	department	salary_range	company_profile	description	requirements	b
0	1	Marketing Intern	US, NY, New York	Marketing	NaN	We're Food52, and we've created a groundbreaki...	Food52, a fast-growing, James Beard Award-winn...	Experience with content management systems a m...	
1	2	Customer Service - Cloud Video Production	NZ, , Auckland	Success	NaN	90 Seconds, the worlds Cloud Video Production ...	Organised - Focused - Vibrant - Awesome!Do you...	What we expect from you:Your key responsibilit...	W usT be
2	3	Commissioning Machinery Assistant (CMA)	US, IA, Wever	NaN	NaN	Valor Services provides Workforce Solutions th...	Our client, located in Houston, is actively se...	Implement pre-commissioning and commissioning ...	
3	4	Account Executive - Washington DC	US, DC, Washington	Sales	NaN	Our passion for improving quality of life thro...	THE COMPANY: ESRI – Environmental Systems Rese...	EDUCATION: Bachelor's or Master's in GIS, busi...	cu a co —v
4	5	Bill Review Manager	US, FL, Fort Worth	NaN	NaN	SpotSource Solutions LLC is a Global Human Cap...	JOB TITLE: Itemization Review ManagerLOCATION:...	QUALIFICATIONS:RN license in the State of Texa...	E

In [ ]:

```
data.tail()
```

Out[ ]:

	job_id	title	location	department	salary_range	company_profile	description	requirements	benefits
17875	17876	Account Director - Distribution	CA, ON, Toronto	Sales	NaN	Vend is looking for some awesome new talent to...	Just in case this is the first time you've vis...	To ace this role you:Will eat comprehensive St...	What can you expect from us? We have an open cu...
17876	17877	Payroll Accountant	US, PA, Philadelphia	Accounting	NaN	WebLinc is the e-commerce platform and service...	The Payroll Accountant will focus primarily on...	- B.A. or B.S. in Accounting- Desire to have f...	Health &amp; WellnessMedical planPrescription ...
17877	17878	Project Cost Control Staff Engineer - Cost Con...	US, TX, Houston	NaN	NaN	We Provide Full Time Permanent Positions for m...	Experienced Project Cost Control Staff Enginee...	At least 12 years professional experience.Abil...	NaN
17878	17879	Graphic Designer	NG, LA, Lagos	NaN	NaN	NaN	Nemsia Studios is looking for an experienced v...	1. Must be fluent in the latest versions of Co...	Competitive salary (compensation will be based...
17879	17880	Web Application Developers	NZ, N, Wellington	Engineering	NaN	Vend is looking for some awesome new talent to...	Who are we?Vend is an award winning web based ...	We want to hear from you if:You have an in-dep...	NaN

In [ ]:

```
data.shape
```

Out[ ]:

```
(17880, 18)
```

In [ ]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 17880 entries, 0 to 17879
Data columns (total 18 columns):
 #   Column               Non-Null Count  Dtype 
---  ------               --------------  ----- 
 0   job_id               17880 non-null  int64 
 1   title                17880 non-null  object
 2   location             17534 non-null  object
 3   department           6333 non-null   object
 4   salary_range         2868 non-null   object
 5   company_profile      14572 non-null  object
 6   description          17879 non-null  object
 7   requirements         15184 non-null  object
 8   benefits             10668 non-null  object
 9   telecommuting        17880 non-null  int64 
 10  has_company_logo     17880 non-null  int64 
 11  has_questions        17880 non-null  int64 
 12  employment_type      14409 non-null  object
 13  required_experience  10830 non-null  object
 14  required_education   9775 non-null   object
 15  industry             12977 non-null  object
 16  function             11425 non-null  object
 17  fraudulent           17880 non-null  int64 
dtypes: int64(5), object(13)
memory usage: 2.5+ MB
```

In [ ]:

```
data.describe()
```

Out[ ]:

	job_id	telecommuting	has_company_logo	has_questions	fraudulent
count	17880.000000	17880.000000	17880.000000	17880.000000	17880.000000
mean	8940.500000	0.042897	0.795302	0.491723	0.048434
std	5161.655742	0.202631	0.403492	0.499945	0.214688
min	1.000000	0.000000	0.000000	0.000000	0.000000
25%	4470.750000	0.000000	1.000000	0.000000	0.000000
50%	8940.500000	0.000000	1.000000	0.000000	0.000000
75%	13410.250000	0.000000	1.000000	1.000000	0.000000
max	17880.000000	1.000000	1.000000	1.000000	1.000000

In [ ]:

```
# Displaying number of duplcates.
data.duplicated().sum()
```

Out[ ]:

```
0
```

In [ ]:

```python
# Calling object columns
object_columns_data = data.select_dtypes(include='object')
object_columns_data.head()
```

Out[ ]:

	title	location	department	salary_range	company_profile	description	requirements	benefits
0	Marketing Intern	US, NY, New York	Marketing	NaN	We're Food52, and we've created a groundbreaki...	Food52, a fast-growing, James Beard Award-winn...	Experience with content management systems a m...	NaN
1	Customer Service - Cloud Video Production	NZ, , Auckland	Success	NaN	90 Seconds, the worlds Cloud Video Production ...	Organised - Focused - Vibrant - Awesome!Do you...	What we expect from you:Your key responsibilit...	What you will get from usThrough being part of...
2	Commissioning Machinery Assistant (CMA)	US, IA, Wever	NaN	NaN	Valor Services provides Workforce Solutions th...	Our client, located in Houston, is actively se...	Implement pre-commissioning and commissioning ...	NaN
3	Account Executive - Washington DC	US, DC, Washington	Sales	NaN	Our passion for improving quality of life thro...	THE COMPANY: ESRI – Environmental Systems Rese...	EDUCATION: Bachelor's or Master's in GIS, busi...	Our culture is anything but corporate—we have ...
4	Bill Review Manager	US, FL, Fort Worth	NaN	NaN	SpotSource Solutions LLC is a Global Human Cap...	JOB TITLE: Itemization Review ManagerLOCATION:...	QUALIFICATIONS:RN license in the State of Texa...	Full Benefits Offered

In [ ]:

```python
# Calling numerical columns
int_columns_data = data.select_dtypes(include='int')
int_columns_data.head()
```

Out[ ]:

	job_id	telecommuting	has_company_logo	has_questions	fraudulent
0	1	0	1	0	0
1	2	0	1	0	0
2	3	0	1	0	0
3	4	0	1	0	0
4	5	0	1	1	0

In [ ]:

```python
data['fraudulent'].value_counts()
```

Out[ ]:

```
fraudulent
0    17014
1      866
Name: count, dtype: int64
```

In [ ]:

```python
real = data[data['fraudulent'] == 0]
real.head(3)
```

Out[ ]:

	job_id	title	location	department	salary_range	company_profile	description	requirements	benefits	telecommut
0	1	Marketing Intern	US, NY, New York	Marketing	NaN	We're Food52, and we've created a groundbreaki...	Food52, a fast-growing, James Beard Award-winn...	Experience with content management systems a m...	NaN	
1	2	Customer Service - Cloud Video Production	NZ, , Auckland	Success	NaN	90 Seconds, the worlds Cloud Video Production ...	Organised - Focused - Vibrant - Awesome!Do you...	What we expect from you:Your key responsibilit...	What you will get from usThrough being part of...	
2	3	Commissioning Machinery Assistant (CMA)	US, IA, Wever	NaN	NaN	Valor Services provides Workforce Solutions th...	Our client, located in Houston, is actively se...	Implement pre-commissioning and commissioning ...	NaN	

In [ ]:

```python
fake = data[data['fraudulent'] == 1]
```

```
fake.head(3)
```

Out[ ]:

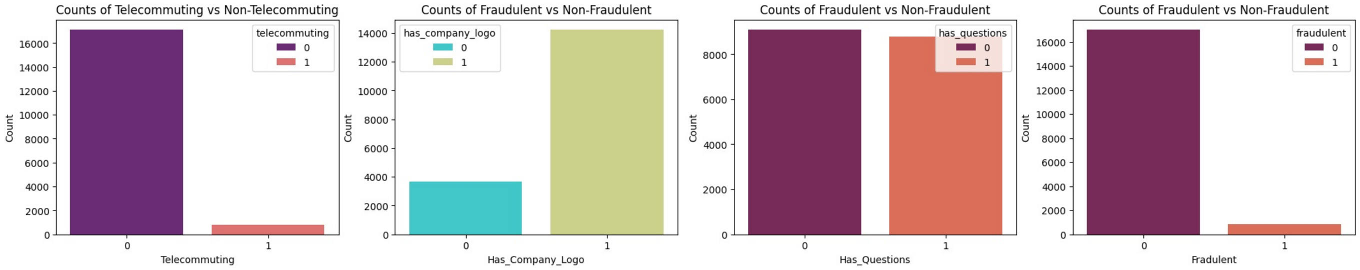
	job_id	title	location	department	salary_range	company_profile	description	requirements	ber
98	99	IC&E Technician	US, , Stocton, CA	Oil & Energy	95000-115000	...	IC&amp;E Technician | Bakersfield, CA Mt. Poso...	QualificationsKnowledge, Skills &amp; Abilitie...	BENEFITSW offered:Compe compen
144	145	Forward Cap.	NaN	NaN	NaN	NaN	The group has raised a fund for the purchase o...	NaN	
173	174	Technician Instrument & Controls	US	Power Plant & Energy	NaN	Edison International and Refined Resources hav...	Technician Instrument &amp; ControlsLocation D...	JOB QUALIFICATIONS-Ability to understand proce...	we are a te almost employees

In [ ]:

```
fraudulent_counts = data['fraudulent'].value_counts()
telecommuting_counts = data['telecommuting'].value_counts()
has_company_logo_counts = data['has_company_logo'].value_counts()
has_questions_counts = data['has_questions'].value_counts()

fig, (ax1, ax2, ax3, ax4) = plt.subplots(1, 4, figsize=(24, 4))


sns.barplot(x=telecommuting_counts.index, y=telecommuting_counts.values, palette='magma', ax=ax1, hue=telecommu
ax1.set_xlabel('Telecommuting')
ax1.set_ylabel('Count')
ax1.set_title('Counts of Telecommuting vs Non-Telecommuting')



sns.barplot(x=has_company_logo_counts.index, y=has_company_logo_counts.values, palette='rainbow', ax=ax2, hue=ha
ax2.set_xlabel('Has_Company_Logo')
ax2.set_ylabel('Count')
ax2.set_title('Counts of Fraudulent vs Non-Fraudulent')


sns.barplot(x=has_questions_counts.index, y=has_questions_counts.values, palette='rocket', ax=ax3, hue=has_ques
ax3.set_xlabel('Has_Questions')
ax3.set_ylabel('Count')
ax3.set_title('Counts of Fraudulent vs Non-Fraudulent')



sns.barplot(x=fraudulent_counts.index, y=fraudulent_counts.values, palette='rocket', ax=ax4, hue=fraudulent_cou
ax4.set_xlabel('Fradulent')
ax4.set_ylabel('Count')
ax4.set_title('Counts of Fraudulent vs Non-Fraudulent')
```

Out[ ]:

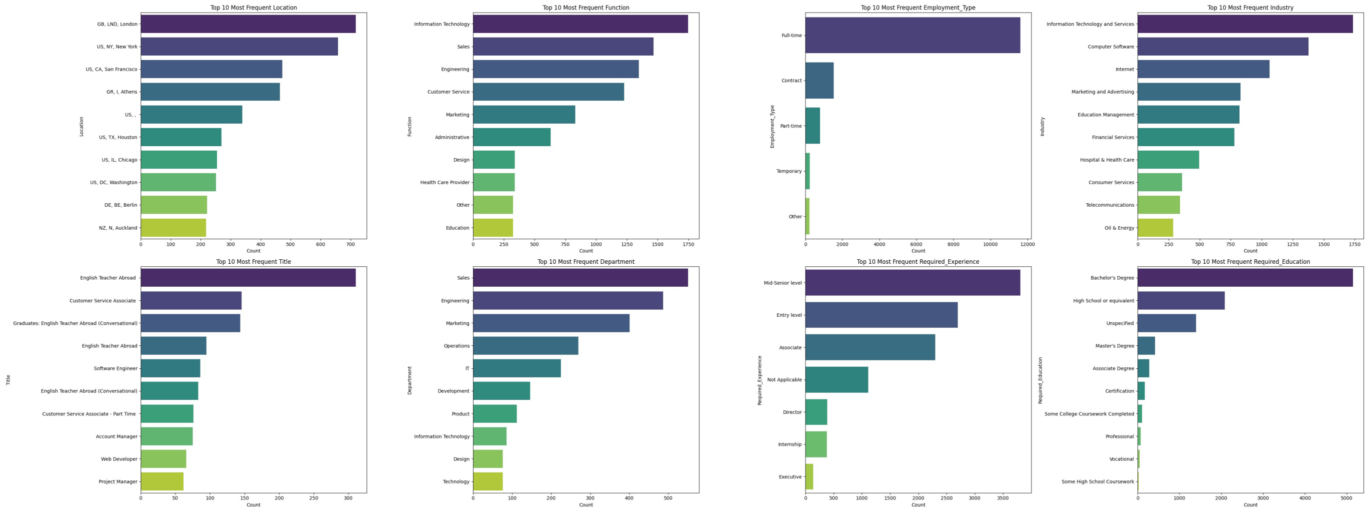
```
Text(0.5, 1.0, 'Counts of Fraudulent vs Non-Fraudulent')
```



In [ ]:

```
title_counts = data['title'].value_counts()
top_10_title = title_counts.head(10)


department_counts = data['department'].value_counts()
top_10_departmant = department_counts.head(10)

industry_counts = data['industry'].value_counts()
top_10_industry = industry_counts.head(10)

required_experience_counts = data['required_experience'].value_counts()
top_10_required_experience = required_experience_counts.head(10)


required_education_counts = data['required_education'].value_counts()
top_10_required_education = required_education_counts.head(10)

employment_type_counts = data['employment_type'].value_counts()
top_10_employment_type = employment_type_counts.head(10)
```

```
location_counts = data['location'].value_counts()
top_10_location = location_counts.head(10)

function_counts = data['function'].value_counts()
top_10_function = function_counts.head(10)


fig, axes = plt.subplots(2, 4, figsize=(40, 15))

sns.barplot(y=top_10_location.index, x=top_10_location.values,hue=top_10_location.index, palette='viridis', ax=a
axes[0][0].set_ylabel('Location')
axes[0][0].set_xlabel('Count')
axes[0][0].set_title('Top 10 Most Frequent Location')


sns.barplot(y=top_10_function.index, x=top_10_function.values,hue=top_10_function.index, palette='viridis', ax=a
axes[0][1].set_ylabel('Function')
axes[0][1].set_xlabel('Count')
axes[0][1].set_title('Top 10 Most Frequent Function')


sns.barplot(y=top_10_employment_type.index, x=top_10_employment_type.values,hue=top_10_employment_type.index, pa
axes[0][2].set_ylabel('Employment_Type')
axes[0][2].set_xlabel('Count')
axes[0][2].set_title('Top 10 Most Frequent Employment_Type')


sns.barplot(y=top_10_industry.index, x=top_10_industry.values, hue=top_10_industry.index, palette='viridis', ax=
axes[0][3].set_ylabel('Industry')
axes[0][3].set_xlabel('Count')
axes[0][3].set_title('Top 10 Most Frequent Industry')



sns.barplot(y=top_10_title.index, x=top_10_title.values,hue=top_10_title.index, palette='viridis', ax=axes[1][0
axes[1][0].set_ylabel('Title')
axes[1][0].set_xlabel('Count')
axes[1][0].set_title('Top 10 Most Frequent Title')


sns.barplot(y=top_10_departmant.index, x=top_10_departmant.values,hue=top_10_departmant.index, palette='viridis
axes[1][1].set_ylabel('Department')
axes[1][1].set_xlabel('Count')
axes[1][1].set_title('Top 10 Most Frequent Department')


sns.barplot(y=top_10_required_experience.index, x=top_10_required_experience.values,hue=top_10_required_experien
axes[1][2].set_ylabel('Required_Experience')
axes[1][2].set_xlabel('Count')
axes[1][2].set_title('Top 10 Most Frequent Required_Experience')



sns.barplot(y=top_10_required_education.index, x=top_10_required_education.values,hue=top_10_required_education
axes[1][3].set_ylabel('Required_Education')
axes[1][3].set_xlabel('Count')
axes[1][3].set_title('Top 10 Most Frequent Required_Education')


plt.tight_layout()

plt.show()
```



Preprocessing

In [ ]:

```
# Dropping job_id column
data = data.drop(columns=['job_id'])
```

In [ ]:

```
# Filling null entries with space.
data.fillna(" ", inplace=True)
```

In [ ]:

```
# Concatinating text columns
concatinated_column = ['title', 'location', 'department', 'salary_range', 'company_profile',
                       'description', 'requirements', 'benefits', 'employment_type',
                       'required_experience', 'required_education', 'industry', 'function']

data['job_posting'] = data[concatinated_column].apply(lambda x: ' '.join(x.dropna().astype(str)), axis=1)
data = data[['job_posting', 'fraudulent']].copy()
```

In [ ]:

```
data.head()
```

Out[ ]:

	job_posting	fraudulent
0	Marketing Intern US, NY, New York Marketing ...	0
1	Customer Service - Cloud Video Production NZ, ...	0
2	Commissioning Machinery Assistant (CMA) US, IA...	0
3	Account Executive - Washington DC US, DC, Wash...	0
4	Bill Review Manager US, FL, Fort Worth Spo...	0

In [ ]:

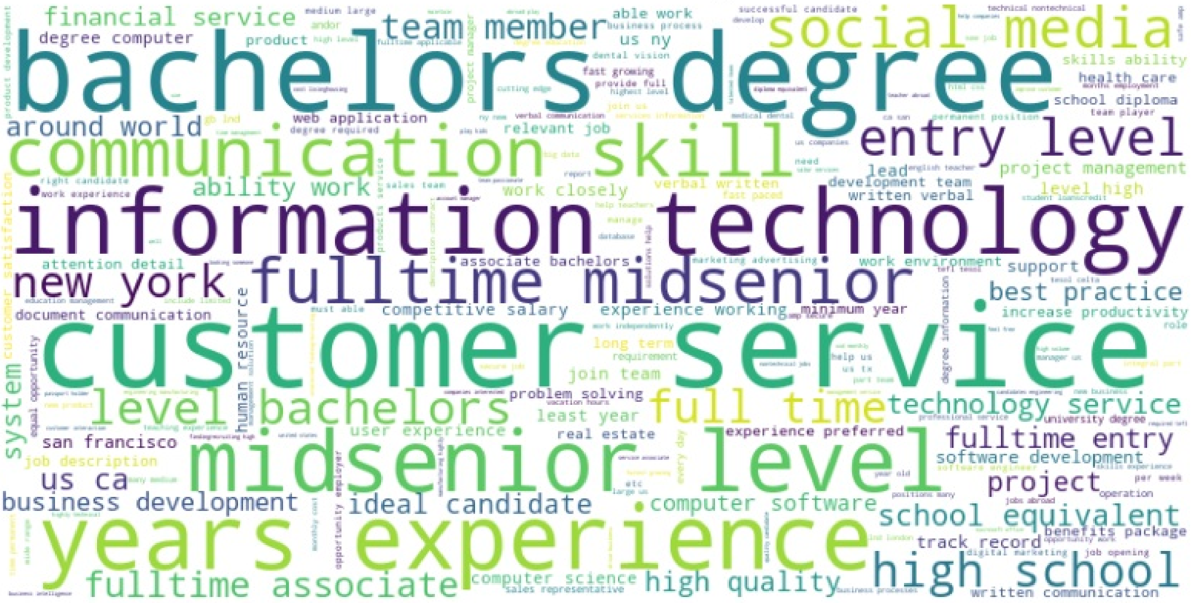
```
# Text cleaning
def preprocess_text(text):
    text = text.lower()     # Convert to lowercase
    text = re.sub(r"http\S+|www\S+|https\S+", "", text, flags=re.MULTILINE)     # Remove URLs
    text = re.sub(r"[^a-zA-Z0-9\s]", "", text)      # Remove special characters
    text = re.sub(r'[^\w\s]', '', text)         # Remove punctuation
    text = re.sub(r'\d', '', text)        # Remove digits

    # Remove stop words
    stop_words = set(stopwords.words('english'))
    words = [word for word in text.split() if word.lower() not in stop_words]
    text = ' '.join(words)

    return text
# Apply the combined function to the 'job_posting' column
data['job_posting'] = data['job_posting'].apply(preprocess_text)
```

WordCloud For Non-Fraudulent Job Postings

In [ ]:

```
real = data[data['fraudulent'] == 0]
text_real = ' '.join(real['job_posting'])
# Create a WordCloud object
wordcloud = WordCloud(width=800, height=400, background_color='white').generate(text_real)

# Display the WordCloud
plt.figure(figsize=(10, 8))
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
plt.title('Word Cloud for Non-Fraudulent Job Postings')
plt.show()
```

Word Cloud for Non-Fraudulent Job Postings

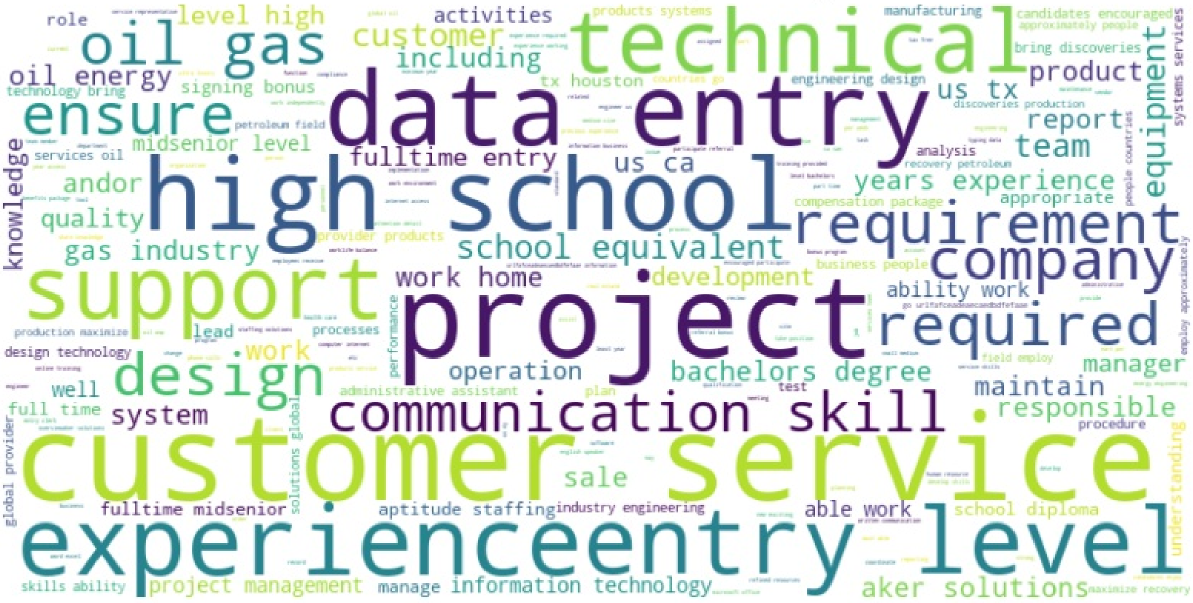


WordCloud For Fraudulent Job Postings

In [ ]:

```
fake = data[data['fraudulent'] == 1]
text_fake = ' '.join(fake['job_posting'])
# Create a WordCloud object
wordcloud = WordCloud(width=800, height=400, background_color='white').generate(text_fake)

# Display the WordCloud
plt.figure(figsize=(10, 8))
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
plt.title('Word Cloud for Fraudulent Job Postings')
plt.show()
```

Word Cloud for Fraudulent Job Postings



Tokenization

In [ ]:

```
# Tokenize each job posting into words
data['job_posting_tokens'] = data['job_posting'].apply(word_tokenize)
# Tokenize each job posting into sentences
data['job_posting_sentences'] = data['job_posting'].apply(sent_tokenize)
```

In [ ]:

```
data.head()
```

Out[ ]:

	job_posting	fraudulent
0	marketing intern us ny new york marketing food...	0
1	customer service cloud video production nz auc...	0
2	commissioning machinery assistant cma us ia we...	0
3	account executive washington dc us dc washingt...	0
4	bill review manager us fl fort worth spotsourc...	0

POS(Parts-Of-Speech) Tagging

In [ ]:

```python
def pos_tagging(sentence):
    tokens = word_tokenize(sentence)
    tagged_tokens = pos_tag(tokens)
    return tagged_tokens
# Apply POS tagging to each sentence in 'job_posting_sentences' column
data['job_posting_pos_tagged'] = data['job_posting_sentences'].apply(lambda x: [pos_tagging(sentence) for sente
```

In [ ]:

```python
data.head()
```

Out[ ]:

	job_posting	fraudulent	job_posting_tokens	job_posting_sentences	job_posting_pos_tagged
0	marketing intern us ny new york marketing food...	0	[marketing, intern, us, ny, new, york, marketi...	[marketing intern us ny new york marketing foo...	[[(marketing, NN), (intern, JJ), (us, PRP), (n...
1	customer service cloud video production nz auc...	0	[customer, service, cloud, video, production, ...	[customer service cloud video production nz au...	[[(customer, NN), (service, NN), (cloud, NN), ...
2	commissioning machinery assistant cma us ia we...	0	[commissioning, machinery, assistant, cma, us,...	[commissioning machinery assistant cma us ia w...	[[(commissioning, VBG), (machinery, NN), (assi...
3	account executive washington dc us dc washingt...	0	[account, executive, washington, dc, us, dc, w...	[account executive washington dc us dc washing...	[[(account, NN), (executive, NN), (washington,...
4	bill review manager us fl fort worth spotsourc...	0	[bill, review, manager, us, fl, fort, worth, s...	[bill review manager us fl fort worth spotsour...	[[(bill, NN), (review, NN), (manager, NN), (us...

N-Grams

In [ ]:

```python
def generate_ngrams(tokens, n):
    return list(ngrams(tokens, n))
# Define the value of n for the n-grams
n = 2
# Apply n-gram generation to the 'job_posting_tokens' column
data['job_posting_ngrams'] = data['job_posting_tokens'].apply(lambda x: generate_ngrams(x, n))
```

In [ ]:

```python
data.head()
```

Out[ ]:

	job_posting	fraudulent	job_posting_tokens	job_posting_sentences	job_posting_pos_tagged	job_posting_ngrams
0	marketing intern us ny new york marketing food...	0	[marketing, intern, us, ny, new, york, marketi...	[marketing intern us ny new york marketing foo...	[[(marketing, NN), (intern, JJ), (us, PRP), (n...	[(marketing, intern), (intern, us), (us, ny), ...
1	customer service cloud video production nz auc...	0	[customer, service, cloud, video, production, ...	[customer service cloud video production nz au...	[[(customer, NN), (service, NN), (cloud, NN), ...	[(customer, service), (service, cloud), (cloud...
2	commissioning machinery assistant cma us ia we...	0	[commissioning, machinery, assistant, cma, us,...	[commissioning machinery assistant cma us ia w...	[[(commissioning, VBG), (machinery, NN), (assi...	[(commissioning, machinery), (machinery, assis...
3	account executive washington dc us dc washingt...	0	[account, executive, washington, dc, us, dc, w...	[account executive washington dc us dc washing...	[[(account, NN), (executive, NN), (washington,...	[(account, executive), (executive, washington)...
4	bill review manager us fl fort worth spotsourc...	0	[bill, review, manager, us, fl, fort, worth, s...	[bill review manager us fl fort worth spotsour...	[[(bill, NN), (review, NN), (manager, NN), (us...	[(bill, review), (review, manager), (manager ...

Named Entity Recognition

In [ ]:

```python
nlp = spacy.load('en_core_web_sm')
# Function to perform Named Entity Recognition
def named_entity_recognition(text):
    doc = nlp(text)
    entities = [(ent.text,ent.label_) for ent in doc.ents if ent.label_ in ['PERSON', 'ORG', 'GPE']]
    return entities
```

```
# Apply NER function to job_description column
data['job_posting_ner'] = data['job_posting'].apply(named_entity_recognition)
```

In [ ]:
```
data.head()
```

Out[ ]:

	job_posting	fraudulent	job_posting_tokens	job_posting_sentences	job_posting_pos_tagged	job_posting_ngrams	job_posting
0	marketing intern us ny new york marketing food...	0	[marketing, intern, us, ny, new, york, marketi...	[marketing intern us ny new york marketing foo...	[[(marketing, NN), (intern, JJ), (us, PRP), (n...	[(marketing, intern), (intern, us), (us, ny), ...	[(new GPE), (plac GPE), (d me
1	customer service cloud video production nz auc...	0	[customer, service, cloud, video, production, ...	[customer service cloud video production nz au...	[[(customer, NN), (service, NN), (cloud, NN), ...	[(customer, service), (service, cloud), (cloud...	[(sony, O (london, G (tokyo, G
2	commissioning machinery assistant cma us ia we...	0	[commissioning, machinery, assistant, cma, us,...	[commissioning machinery assistant cma us ia w...	[[(commissioning, VBG), (machinery, NN), (assi...	[(commissioning, machinery), (machinery, assis...	[(houston, G
3	account executive washington dc us dc washingt...	0	[account, executive, washington, dc, us, dc, w...	[account executive washington dc us dc washing...	[[(account, NN), (executive, NN), (washington,...	[(account, executive), (executive, washington)...	[(washin GPE), (us, G (washin G
4	bill review manager us fl fort worth spotsourc...	0	[bill, review, manager, us, fl, fort, worth, s...	[bill review manager us fl fort worth spotsour...	[[(bill, NN), (review, NN), (manager, NN), (us...	[(bill, review), (review, manager), (manager, ...	[(florida, G (tx depart itemization

Vectorizing The Text Data

In [ ]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(data['job_posting_tokens'], data['fraudulent'], test_size=0

# Flatten the list of lists into a single list of strings
X_train_flattened = [' '.join(sublist) for sublist in X_train]

# Vectorize the text data
vectorizer = CountVectorizer()
X_train_vec = vectorizer.fit_transform(X_train_flattened)

# Flatten the list of lists into a single list of strings for test data
X_test_flattened = [' '.join(sublist) for sublist in X_test]
X_test_vec = vectorizer.transform(X_test_flattened)
```

In [ ]:
```
# Ensure the shape of X_train_vec matches the number of samples in X_train
print("Shape of X_train_vec:", X_train_vec.shape)
print("Number of samples in X_train:", X_train.shape[0])

# Ensure the shape of X_test_vec matches the number of samples in X_test
print("Shape of X_test_vec:", X_test_vec.shape)
print("Number of samples in X_test:", X_test.shape[0])
```

```
Shape of X_train_vec: (14304, 138280)
Number of samples in X_train: 14304
Shape of X_test_vec: (3576, 138280)
Number of samples in X_test: 3576
```

Splitting

In [ ]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X_train_vec, y_train, test_size=0.2, random_state=42)
```

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