Module 6.2 Assignment: Preparing Data for Final Team Project

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```
# Imports
import requests
from bs4 import BeautifulSoup
import pandas as pd
import io
from PyPDF2 import PdfReader
import numpy as np
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.metrics.pairwise import linear_kernel
import nltk
from nltk.tokenize import sent_tokenize, word_tokenize
import re
import string
from nltk.corpus import stopwords
nltk.download('stopwords')
sw = stopwords.words("english")
nltk.download('wordnet')
import warnings
warnings.filterwarnings('ignore')
from transformers import BartTokenizer, BartForConditionalGeneration,
pipeline
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.decomposition import LatentDirichletAllocation
import matplotlib.pyplot as plt
import seaborn as sns
from wordcloud import WordCloud
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\trevor.sauerbrey\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     C:\Users\trevor.sauerbrey\AppData\Roaming\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

```
def fetch_arxiv_data(search_query, max_results=10, start_date=None,
end_date=None, primary_category=None, categories=None):
    """
    Fetches data from the arXiv API based on specified parameters.

    Parameters:
        search_query (str): The search query string.
        max_results (int): The maximum number of results to retrieve
(default is 10).
        start_date (str): The start date for the search query in the
format 'YYYY-MM-DD'.
        end_date (str): The end date for the search query in the
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format 'YYYY-MM-DD'.
        primary_category (str): The primary category of the articles.
        categories (str): Additional categories for the articles.

    Returns:
        DataFrame: A pandas DataFrame containing the fetched arXiv
data.
    """
    api_url = "http://export.arxiv.org/api/query"  # Defining the API
URL for arXiv
    params = {
        "search_query": search_query,  # Setting search query
parameter
        "start": 0,  # Setting start parameter for pagination
        "max_results": max_results,  # Setting maximum results
parameter
    }
    if start_date:
        params["start_date"] = start_date  # Adding start date
parameter if provided
    if end_date:
        params["end_date"] = end_date  # Adding end date parameter if
provided
    if primary_category:
        params["cat"] = primary_category  # Adding primary category
parameter if provided
    if categories:
        params["categories"] = categories  # Adding additional
categories parameter if provided

    response = requests.get(api_url, params=params)  # Making a GET
request to arXiv API with specified parameters
    if response.status_code == 200:  # Checking if the request was
successful
        feed = BeautifulSoup(response.content, features="html.parser")
# Parsing the response content using BeautifulSoup
        entries = feed.find_all('entry')  # Finding all 'entry'
elements in the parsed content
        articles = []

        for entry in entries:  # Looping through each entry
            article = {}  # Creating an empty dictionary to store
article data
            article['Title'] = entry.title.text  # Extracting title of
the article
            article['Authors'] = [author.find('name').text for author
in entry.find_all('author')]  # Extracting authors of the article
            article['Published'] = entry.published.text  # Extracting
publication date
            article['Updated'] = entry.updated.text  # Extracting last
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updated date
            article['Summary'] = entry.summary.text.strip()  # 
Extracting summary of the article
            article['ID'] = entry.id.text  # Extracting unique ID of 
the article
            articles.append(article)  # Appending article data to the 
list

        df = pd.DataFrame(articles)  # Creating a pandas DataFrame 
from the list of articles
        return df  # Returning the DataFrame
    else:
        print("Failed to retrieve data from arXiv API")  # Printing 
error message if request fails
        return None

def download_pdf_from_link(link):
    """
    Downloads a PDF file from the given URL.

    Parameters:
        link (str): The URL of the PDF file.

    Returns:
        io.BytesIO or None: BytesIO object containing the PDF content 
if successful, else None.
    """
    response = requests.get(link, stream=True)  # Making a GET request 
to download the PDF file
    if response.status_code == 200:  # Checking if the request was 
successful
        return io.BytesIO(response.content)  # Returning BytesIO 
object containing the PDF content
    else:
        print(f"Failed to download PDF from {link}")  # Printing error 
message if download fails
        return None

def extract_text_from_pdf(pdf_io):
    """
    Extracts text from a PDF file.

    Parameters:
        pdf_io (io.BytesIO): BytesIO object containing the PDF 
content.

    Returns:
        str: Extracted text from the PDF.
    """
    if pdf_io:
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        try:
            reader = PdfReader(pdf_io)  # Creating a PdfReader object with the PDF content
            text = ""
            for page in reader.pages:  # Looping through each page in the PDF
                text += page.extract_text() + "\n"  # Extracting text from the page and appending it to the 'text' variable
            return text  # Returning the extracted text
        except Exception as e:
            print(f"Error occurred while extracting text from PDF: {str(e)}")  # Printing error message if extraction fails
            return ""

def process_pdf_links(df):
    """
    Processes PDF links in a DataFrame by downloading and extracting text from them.

    Parameters:
        df (DataFrame): The pandas DataFrame containing PDF links.

    Returns:
        DataFrame: The DataFrame with an additional column containing extracted text from PDFs.
    """
    df['PDF_Text'] = ''  # Adding an empty column 'PDF_Text' to the DataFrame
    for index, row in df.iterrows():  # Looping through each row in the DataFrame
        link = row['ID']  # Extracting the PDF link from the 'ID' column
        # We need to convert the '/abs/' URL to a '/pdf/' URL and ensure it ends with '.pdf'
        link = link.replace('abs', 'pdf')  # Replacing 'abs' with 'pdf' in the URL
        if not link.endswith('.pdf'):  # Checking if the link ends with '.pdf'
            link += '.pdf'  # Appending '.pdf' to the link if it doesn't end with it already
        print(f"Processing link: {link}")  # Printing the processed link
        pdf_io = download_pdf_from_link(link)  # Downloading the PDF file
        if pdf_io:  # Checking if PDF download was successful
            text = extract_text_from_pdf(pdf_io)  # Extracting text from the PDF
            df.at[index, 'PDF_Text'] = text  # Adding the extracted text to the 'PDF_Text' column in the DataFrame
    return df  # Returning the updated DataFrame
```

```
def preprocess_text(text):
    """
    Preprocesses the text by converting it to lowercase, removing
digits, and removing punctuation.

    Parameters:
        text (str): The input text to be preprocessed.

    Returns:
        str: The preprocessed text.
    """
    text = text.lower()  # Convert text to lowercase
    text = re.sub(r'\d+', '', text)  # Remove digits
    text = re.sub(r'[^\w\s]', '', text)  # Remove punctuation
    return text

def remove_stopwords(tokens):
    """
    Removes stopwords from the list of tokens.

    Parameters:
        tokens (list): List of tokens.

    Returns:
        list: Tokens with stopwords removed.
    """
    stop_words = set(stopwords.words('english'))
    filtered_tokens = [word for word in tokens if word not in
stop_words]
    return filtered_tokens

def perform_lemmatization(tokens):
    """
    Performs lemmatization on the list of tokens.

    Parameters:
        tokens (list): List of tokens.

    Returns:
        list: Lemmatized tokens.
    """
    lemmatizer = nltk.WordNetLemmatizer()
    lemmatized_tokens = [lemmatizer.lemmatize(token) for token in
tokens]
    return lemmatized_tokens

def clean_text(text):
    """
    Cleans the text by preprocessing, removing stopwords, and
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performing lemmatization.

    Parameters:
        text (str): The input text to be cleaned.

    Returns:
        str: The cleaned text.
    """
    # Preprocess the text
    text = preprocess_text(text)

    # Tokenize the text
    tokens = word_tokenize(text)

    # Remove stopwords
    filtered_tokens = remove_stopwords(tokens)

    # Perform lemmatization
    lemmatized_tokens = perform_lemmatization(filtered_tokens)

    # Join the lemmatized tokens into a string
    cleaned_text = ' '.join(lemmatized_tokens)

    return cleaned_text

def clean_and_tokenize(text):
    """
    Cleans and tokenizes the given text.

    Parameters:
        text (str): The input text to be cleaned and tokenized.

    Returns:
        list: The list of cleaned and tokenized words.
    """
    if text is None:
        return []  # Return an empty list if the text is None

    # Remove punctuation characters
    text = ''.join([char for char in text if char not in
string.punctuation])

    # Tokenize the text
    tokens = word_tokenize(text)

    # Remove stopwords
    stop_words = set(stopwords.words('english'))
    tokens = [word for word in tokens if word.lower() not in
stop_words]
```

```
    return tokens

def descriptive_stats(tokens_list, num_tokens=5, verbose=True):
    """
    Given a list of lists of tokens, print number of tokens, number of
unique tokens,
    number of characters, lexical diversity, and num_tokens most
common tokens.
    Return a list with the number of tokens, number of unique tokens,
    lexical diversity, and number of characters.

    """

    # Flatten the list of lists into a single list
    tokens = [token for sublist in tokens_list for token in sublist]

    # Fill in the correct values here.
    num_tokens = len(tokens)
    num_unique_tokens = len(set(tokens))

    # Check if num_tokens is zero to avoid ZeroDivisionError
    if num_tokens == 0:
        return [0, 0, 0.0, 0]  # Return appropriate values when there
are no tokens

    lexical_diversity = num_unique_tokens / num_tokens
    num_characters = sum([len(token) for token in tokens])

    if verbose:
        print(f"There are {num_tokens} tokens in the data.")
        print(f"There are {num_unique_tokens} unique tokens in the
data.")
        print(f"There are {num_characters} characters in the data.")
        print(f"The lexical diversity is {lexical_diversity:.3f} in
the data.")

    # print the five most common tokens

    return [num_tokens, num_unique_tokens,
            lexical_diversity,
            num_characters]

# Example usage
df = fetch_arxiv_data(search_query="quantum physics", max_results=100,
primary_category="quant-ph", categories=["quant-ph"])
df_with_pdf_text = process_pdf_links(df)
df_with_pdf_text
```

```
Processing link: http://arxiv.org/pdf/quant-ph/0302169v1.pdf
Processing link: http://arxiv.org/pdf/1212.4177v1.pdf
```

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Processing link: http://arxiv.org/pdf/1504.03207v1.pdf
Processing link: http://arxiv.org/pdf/2208.08064v1.pdf
Processing link: http://arxiv.org/pdf/cond-mat/0601285v1.pdf
Processing link: http://arxiv.org/pdf/0811.2516v1.pdf
Processing link: http://arxiv.org/pdf/1807.11019v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0201082v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0309066v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0504224v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0703105v1.pdf
Processing link: http://arxiv.org/pdf/2111.15352v4.pdf
Processing link: http://arxiv.org/pdf/1704.07976v1.pdf
Processing link: http://arxiv.org/pdf/1310.8457v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0407102v1.pdf
Processing link: http://arxiv.org/pdf/0804.3401v1.pdf
Processing link: http://arxiv.org/pdf/1611.03472v1.pdf
Processing link: http://arxiv.org/pdf/1311.4939v1.pdf
Processing link: http://arxiv.org/pdf/math-ph/0104010v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0001061v1.pdf
Processing link: http://arxiv.org/pdf/1210.0736v1.pdf
Processing link: http://arxiv.org/pdf/2205.04243v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0304079v1.pdf
Processing link: http://arxiv.org/pdf/0906.1605v1.pdf
Processing link: http://arxiv.org/pdf/0804.0180v2.pdf
Processing link: http://arxiv.org/pdf/1611.07851v2.pdf
Processing link: http://arxiv.org/pdf/1111.3940v1.pdf
Processing link: http://arxiv.org/pdf/1301.4612v1.pdf
Processing link: http://arxiv.org/pdf/1902.05837v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/9811006v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0303098v1.pdf
Processing link: http://arxiv.org/pdf/1408.2836v1.pdf
Processing link: http://arxiv.org/pdf/1301.3407v1.pdf
Processing link: http://arxiv.org/pdf/2309.17377v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0303117v1.pdf
Processing link: http://arxiv.org/pdf/0912.3095v1.pdf
Processing link: http://arxiv.org/pdf/2203.15464v1.pdf
Processing link: http://arxiv.org/pdf/0907.3802v1.pdf
Processing link: http://arxiv.org/pdf/2311.06029v1.pdf
Processing link: http://arxiv.org/pdf/hep-th/9608016v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/9603028v1.pdf
Processing link: http://arxiv.org/pdf/1204.5172v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0309070v2.pdf
Processing link: http://arxiv.org/pdf/quant-ph/9904037v1.pdf
Processing link: http://arxiv.org/pdf/1404.2784v1.pdf
Processing link: http://arxiv.org/pdf/2210.05133v1.pdf
Processing link: http://arxiv.org/pdf/hep-th/9412047v1.pdf
Processing link: http://arxiv.org/pdf/1109.3507v1.pdf
Processing link: http://arxiv.org/pdf/1208.5524v1.pdf
Processing link: http://arxiv.org/pdf/1705.05099v1.pdf
Processing link: http://arxiv.org/pdf/0708.3751v1.pdf
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Processing link: http://arxiv.org/pdf/0709.0340v1.pdf
Processing link: http://arxiv.org/pdf/1006.4610v1.pdf
Processing link: http://arxiv.org/pdf/1207.2419v1.pdf
Processing link: http://arxiv.org/pdf/1304.4425v1.pdf
Processing link: http://arxiv.org/pdf/0708.0261v1.pdf
Processing link: http://arxiv.org/pdf/2004.01329v1.pdf
Processing link: http://arxiv.org/pdf/1211.0803v1.pdf
Processing link: http://arxiv.org/pdf/2302.10216v1.pdf
Processing link: http://arxiv.org/pdf/2006.03757v1.pdf
Processing link: http://arxiv.org/pdf/0812.4614v2.pdf
Processing link: http://arxiv.org/pdf/0907.0980v3.pdf
Processing link: http://arxiv.org/pdf/2305.15648v2.pdf
Processing link: http://arxiv.org/pdf/2208.06306v1.pdf
Processing link: http://arxiv.org/pdf/1201.4780v2.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0503073v1.pdf
Processing link: http://arxiv.org/pdf/1107.5907v1.pdf
Processing link: http://arxiv.org/pdf/1404.0552v1.pdf
Processing link: http://arxiv.org/pdf/2008.07914v2.pdf
Processing link: http://arxiv.org/pdf/2112.00199v1.pdf
Error occurred while extracting text from PDF: EOF marker not found
Processing link: http://arxiv.org/pdf/1601.02313v1.pdf
Processing link: http://arxiv.org/pdf/2210.02398v1.pdf
Processing link: http://arxiv.org/pdf/1402.1141v1.pdf
Processing link: http://arxiv.org/pdf/2202.12656v2.pdf
Processing link: http://arxiv.org/pdf/1507.03200v1.pdf
Processing link: http://arxiv.org/pdf/2211.08567v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0002077v3.pdf
Processing link: http://arxiv.org/pdf/1802.00736v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/9805068v1.pdf
Processing link: http://arxiv.org/pdf/0811.3015v1.pdf
Processing link: http://arxiv.org/pdf/1603.05778v1.pdf
Processing link: http://arxiv.org/pdf/1007.4469v1.pdf
Processing link: http://arxiv.org/pdf/1711.06561v1.pdf
Processing link: http://arxiv.org/pdf/1311.0277v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0011093v1.pdf
Processing link: http://arxiv.org/pdf/1401.0896v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/9610012v1.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0305017v1.pdf
Processing link: http://arxiv.org/pdf/1503.00039v1.pdf
Processing link: http://arxiv.org/pdf/1703.05342v1.pdf
Processing link: http://arxiv.org/pdf/1903.02910v1.pdf
Processing link: http://arxiv.org/pdf/cond-mat/0102019v1.pdf
Processing link: http://arxiv.org/pdf/2103.07712v2.pdf
Processing link: http://arxiv.org/pdf/2010.02931v2.pdf
Processing link: http://arxiv.org/pdf/2312.12800v1.pdf
Processing link: http://arxiv.org/pdf/2111.04002v2.pdf
Processing link: http://arxiv.org/pdf/2011.13143v2.pdf
Processing link: http://arxiv.org/pdf/2108.13421v2.pdf
```

```
Processing link: http://arxiv.org/pdf/2207.05213v2.pdf
Processing link: http://arxiv.org/pdf/quant-ph/0206091v1.pdf

                                                Title
Authors  \
0  Nonlinear Dynamics In Quantum Physics -- Quant...          [H.
Kröger]
1                            Quantum spherical model          [I.
Lyberg]
2  Can classical physics agree with quantum physi...  [Michele
Marrocco]

               Published                Updated  \
0  2003-02-21T20:20:47Z  2003-02-21T20:20:47Z
1  2012-12-17T22:06:56Z  2012-12-17T22:06:56Z
2  2015-04-13T15:04:26Z  2015-04-13T15:04:26Z

                                             Summary  \
0  We discuss the recently proposed quantum actio...
1  We define a "quantum spherical model", a quant...
2  Classical physics fails where quantum physics ...

                                          ID  \
0  http://arxiv.org/abs/quant-ph/0302169v1
1        http://arxiv.org/abs/1212.4177v1
2       http://arxiv.org/abs/1504.03207v1

                                            PDF_Text
0  arXiv:quant-ph/0302169v1  21 Feb 2003PROCEEDIN...
1  arXiv:1212.4177v1  [math-ph]  17 Dec 2012A “qu...
2   1 Can classical physics agree with quant um p...
```

```
df_with_pdf_text['pdf_tokens'] =
df_with_pdf_text['PDF_Text'].apply(clean_and_tokenize)
df_with_pdf_text.head(3)
```

```
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```
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                                            PDF_Text  \
0  arXiv:quant-ph/0302169v1  21 Feb 2003PROCEEDIN...
1  arXiv:1212.4177v1  [math-ph]  17 Dec 2012A “qu...
2   1 Can classical physics agree with quant um p...

                                          pdf_tokens
0  [arXivquantph0302169v1, 21, Feb, 2003PROCEEDIN...
1  [arXiv12124177v1, mathph, 17, Dec, 2012A, “, q...
2  [1, classical, physics, agree, quant, um, phys...
```

```python
# Apply descriptive_stats function to pdf_tokens column
stats = descriptive_stats(df_with_pdf_text['pdf_tokens'])

# Print the descriptive statistics
print("Descriptive Statistics for pdf_tokens:")
print(f"Number of Tokens: {stats[0]}")
print(f"Number of Unique Tokens: {stats[1]}")
print(f"Lexical Diversity: {stats[2]:.3f}")
print(f"Number of Characters: {stats[3]}")
```

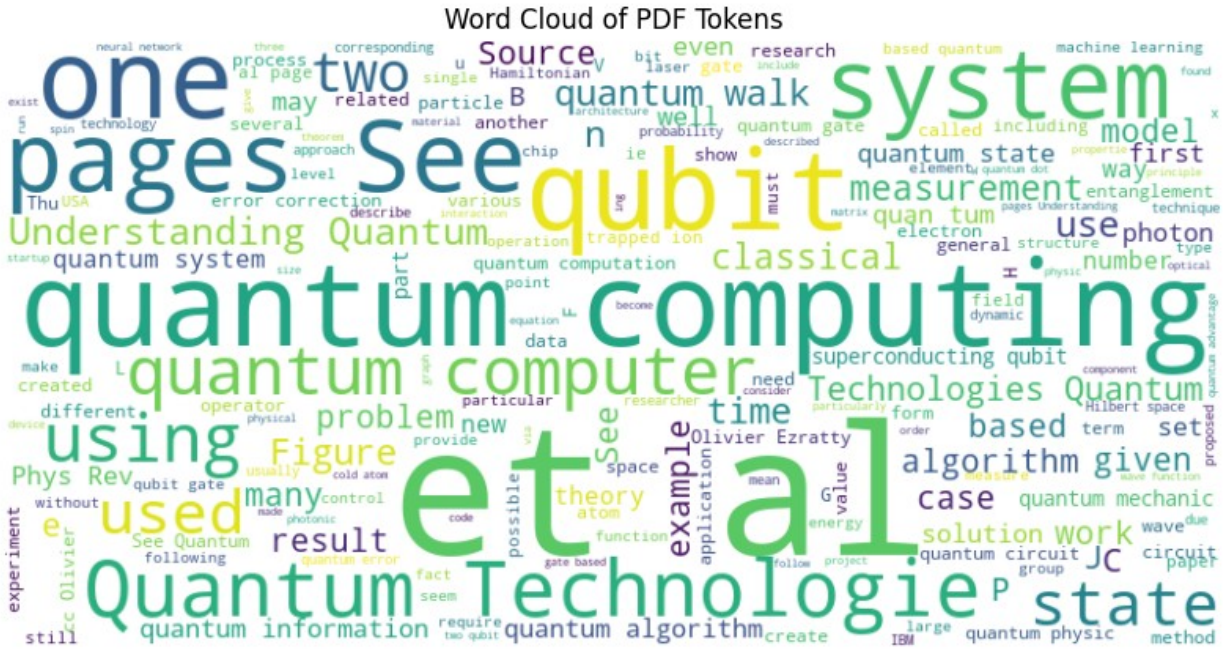
```
There are 979965 tokens in the data.
There are 110857 unique tokens in the data.
There are 6236040 characters in the data.
The lexical diversity is 0.113 in the data.
Descriptive Statistics for pdf_tokens:
Number of Tokens: 979965
Number of Unique Tokens: 110857
Lexical Diversity: 0.113
Number of Characters: 6236040
```

```python
# Combine all tokens into a single string
all_tokens = ' '.join(df_with_pdf_text['pdf_tokens'].sum())

# Create the WordCloud object
wordcloud = WordCloud(width=800, height=400,
background_color='white').generate(all_tokens)

# Display the word cloud
plt.figure(figsize=(10, 6))
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
```

```
plt.title('Word Cloud of PDF Tokens')
plt.show()
```



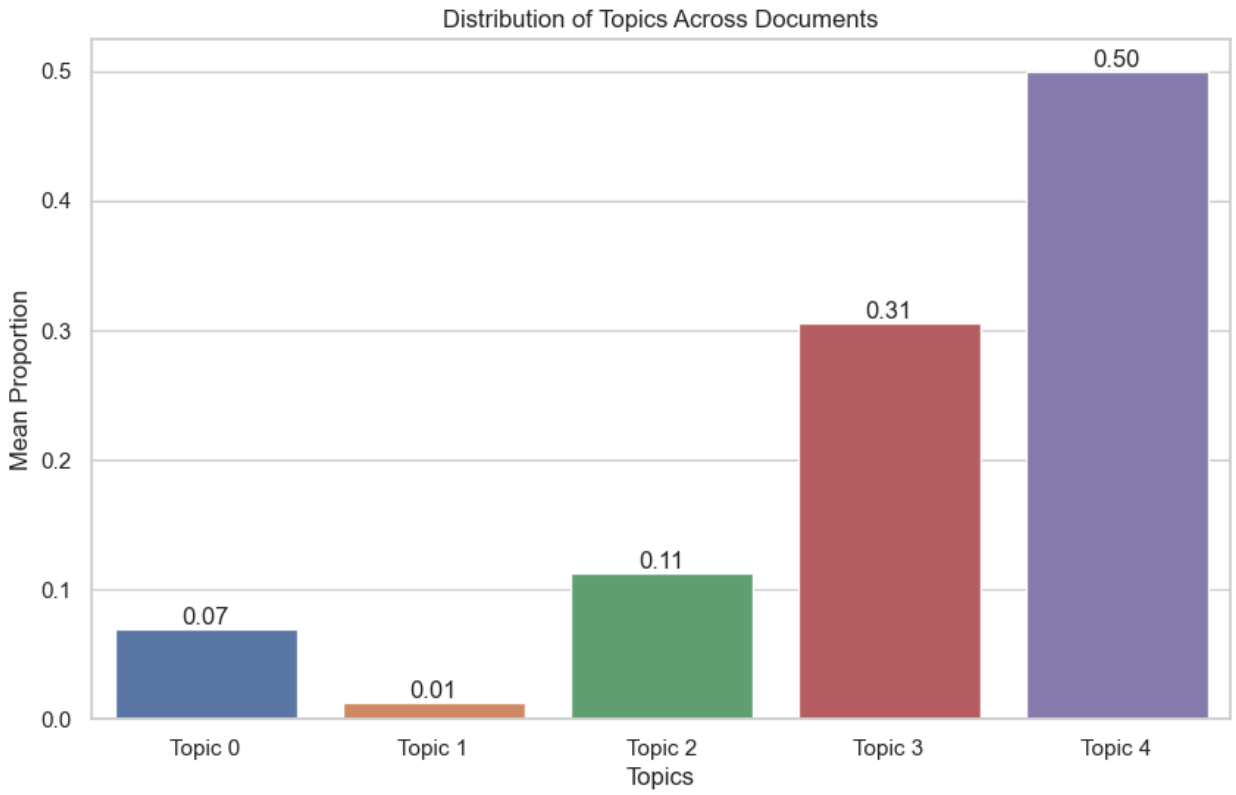

```
# Vectorize the text data
vectorizer = CountVectorizer(max_features=5000, max_df=0.95, min_df=2,
stop_words='english')
X = vectorizer.fit_transform(df_with_pdf_text['PDF_Text'])

# Apply LDA
num_topics = 5  # You can adjust the number of topics
lda = LatentDirichletAllocation(n_components=num_topics,
random_state=42)
lda.fit(X)

# Visualize the distribution of topics across documents
topic_distribution = lda.transform(X)
sns.set(style="whitegrid")
plt.figure(figsize=(10, 6))
ax = sns.barplot(x=[f"Topic {i}" for i in range(num_topics)],
y=topic_distribution.mean(axis=0))
plt.title('Distribution of Topics Across Documents')
plt.xlabel('Topics')
plt.ylabel('Mean Proportion')

# Add numbers to the bars
for i, mean_proportion in enumerate(topic_distribution.mean(axis=0)):
    ax.text(i, mean_proportion, f'{mean_proportion:.2f}', ha='center',
va='bottom')
```

```
plt.show()
```


Distribution of Topics Across Documents
Mean Proportion
0.0
0.1
0.2
0.3
0.4
0.5
0.07
0.01
0.11
0.31
0.50
Topic 0
Topic 1
Topic 2
Topic 3
Topic 4
Topics