TOPIC MODELING ON NEW YORK TIMES ARTICLES

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INTRODUCTION

This research project delves into the efficacy of four distinct topic modelling algorithms—Latent Semantic Analysis (LSA), Latent Dirichlet Allocation (LDA), Non-Negative Matrix Factorization (NMF), and BERT-based topic modelling—applied to a corpus of New York Times articles. The New York Times, as a prominent source of news, produces a plethora of articles spanning various topics daily. The objective is to extract meaningful topics from this corpus, shedding light on prevalent themes covered by the publication. In the digital age, managing and comprehending vast amounts of textual data pose challenges, particularly in news analysis. Traditional methods like LSA and NMF have been augmented by advanced techniques such as LDA and BERT-based models, capable of capturing intricate semantic relationships. This project aims to evaluate the effectiveness of each algorithm in terms of topic coherence and interpretability, contributing to the advancement of topic modelling techniques in news analysis.

RELATED WORK

In recent years, the application of topic modelling techniques, including Latent Dirichlet Allocation (LDA), Non-Negative Matrix Factorization (NMF), BERT-based models, and Latent Semantic Analysis (LSA), has gained prominence in the analysis of textual data, particularly news articles. Studies by Nguyen et al. (2015) and Zhu et al. (2017) have demonstrated the effectiveness of LDA and NMF, respectively, in uncovering prevalent themes and trends within diverse news sources. Additionally, the emergence of BERT-based models, pioneered by Devlin et al. (2019), has introduced new possibilities in natural language processing tasks, including topic modelling. LSA, another widely used technique, has also shown promise in extracting latent thematic structures from textual data. Despite individual investigations into these algorithms, there remains a gap in comparative research, particularly within the context of analyzing New York Times articles. This study aims to address this gap by conducting a comprehensive comparison of LDA, NMF, BERT-based, and LSA topic modelling techniques. Each method will be evaluated for its ability to extract meaningful topics from the corpus of New York Times articles, contributing not only to topic modelling research but also enhancing our understanding of news analysis methodologies.

METHODOLOGY

The methodologies employed in this study encompass a comprehensive comparison of four distinct topic modelling algorithms: Latent Semantic Analysis (LSA), Latent Dirichlet Allocation (LDA), Non-Negative Matrix Factorization (NMF), and BERT-based topic modelling. Each algorithm will be applied to the dataset of New York Times articles, with careful consideration given to parameter tuning and preprocessing techniques to optimize performance. Evaluation metrics such as topic coherence and interpretability will be utilized to assess the effectiveness of each algorithm in uncovering latent thematic structures within the corpus. Additionally, visualization techniques, including word clouds and topic-word matrices, will be employed to provide further insights into the extracted topics.

The data preprocessing stage involves converting the text file containing articles into a structured CSV format. This process includes extracting URLs and content from the text file, as well as parsing URLs to extract dates, news categories, and headlines. This structured organization enables efficient handling and allows for chronological, categorical, and concise representation of the content. The extracted information is then organized into a DataFrame for analysis, facilitating trend analysis over time and category-wise content analysis. Text preprocessing using NLTK stopwords removes irrelevant words, enhancing the quality of the data. With potential for visualization using matplotlib and seaborn, the extracted data offers insights for both analysis and presentation. The code's flexibility and scalability allow for adaptation to handle larger datasets and perform more complex analyses, making it versatile for various application scenarios such as news trend analysis and key information extraction from articles.

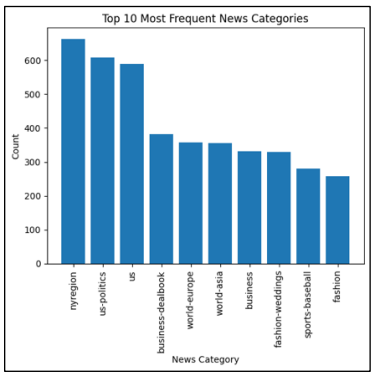

Fig:1 Top 10 Most Frequent News Categories

Latent Semantic Analysis (LSA)

The preprocessed text was utilized to construct a dictionary representation and corpus essential for the LSA model. Following data preparation, the LSA model was instantiated using Gensim's LsiModel class, with the number of topics set to 10, albeit adjustable for finer granularity. The model was then trained on the corpus of documents to unearth latent topics inherent in the data. For each topic, top contributing words were extracted and visualized using both word clouds and bar plots, facilitating a comprehensive understanding of the underlying themes. The results were further elucidated through visual aids such as word clouds and bar plots, showcasing the most significant words contributing to each topic along with their respective TF-IDF weights.

```
  sports-baseball nyregion nyregion nyregion sports-olympics sports-olympics
0              mr     said     year      one           would             like
1              mr    trump     year      one            said          clinton
2            said    trump       ms     game      republican          clinton
3          school     game     said  student            team             play
4          school  compani    state       mr              ms          percent
5            said  compani    trump       mr           state              new
6          school     game  percent    peopl              ms                1
7           trump     said    state       ms              mr          compani
8           trump    polic       ms    offic        european             citi
9            citi  compani      new    court            hous            would
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: Deprecatio
  and should_run_async(code)
```

Fig: 2 Topic-Word Matrix

```
Topic: sports-baseball
Words: 0.457*"mr" + 0.450*"said" + 0.165*"year" + 0.149*"one" + 0.141*"would" + 0.
Topic: nyregion
Words: -0.749*"mr" + -0.281*"trump" + 0.134*"year" + 0.123*"one" + 0.117*"said" +
Topic: nyregion
Words: -0.520*"said" + 0.462*"trump" + -0.167*"ms" + 0.158*"game" + 0.141*"republi
Topic: nyregion
Words: 0.445*"school" + -0.322*"game" + -0.242*"said" + 0.169*"student" + -0.158*"
Topic: sports-olympics
Words: 0.425*"school" + -0.259*"compani" + -0.213*"state" + 0.203*"mr" + 0.157*"ms
```

Fig: 3 Topic Representation

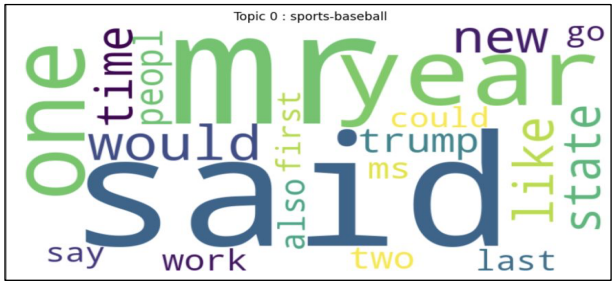

Fig: 4 Word Cloud Visualization

Latent Dirichlet Allocation (LDA)

A dictionary was created to map words to unique numerical IDs, and a corpus was generated using the Bag of Words representation. The LDA model was then trained on the corpus, with specified parameters including the number of topics (30), passes (20), and iterations (100). Visualizing the trained model's topics was facilitated by employing the pyLDAvis library, with word clouds and heatmap visualizations aiding in the exploration of the top words contributing to each topic. Evaluation of the model's coherence and interpretability was conducted by computing the coherence score using the c_v coherence metric, providing insights into the quality of the extracted topics.

```
Topic: sports-baseball
Words: 0.015*"said" + 0.014*"6" + 0.012*"year" + 0.012*"open" + 0.011*"sh
Topic: nyregion
Words: 0.027*"game" + 0.019*"point" + 0.013*"said" + 0.011*"curri" + 0.0
```

Fig: 5 Topic Representation

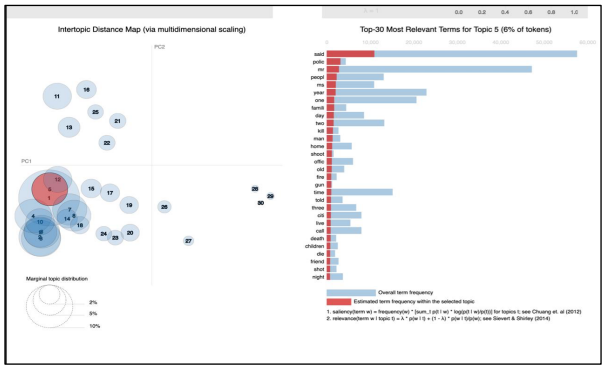

Fig: 6 PyLDAvis

Non-Negative Matrix Factorization (NMF)

NMF was chosen as the framework for topic modeling, leveraging its capability to extract latent topics from the dataset. The number of topics was set to 10, providing a reasonable balance between granularity and interpretability, while a random state of 5 was employed for reproducibility purposes, ensuring consistent results across multiple runs. In the evaluation phase, the interpretability and coherence of the identified topics were rigorously assessed. This involved scrutinizing the relevance and significance of the top words associated with each topic. Additionally, word clouds and stacked area charts were generated to visualize the distribution of topics and the importance of words within each topic, offering deeper insights into the thematic composition of the dataset. Through these comprehensive evaluation techniques, the efficacy of NMF in uncovering meaningful topics from the text corpus was thoroughly examined and validated.

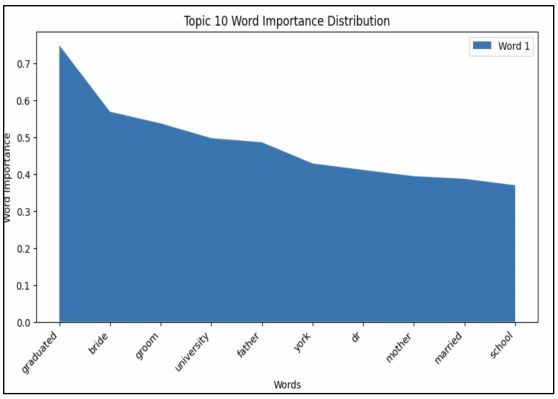

Fig: 7 Stacked Area Chart

BERTopic

The BERTopic model was applied to the tokenized articles, where it automatically identified topics within the dataset. These topics were subsequently assigned labels for further analysis, enabling the extraction of meaningful insights from the corpus. In the analysis and visualization stage, a comprehensive examination of the top news categories and topics was conducted. This involved exploring the distribution of topics across the dataset and examining the relationships between them. Word clouds were generated to visually represent the most frequent words associated with each topic, offering a concise summary of their thematic content. Additionally, an Intertopic Distance Map was constructed to visualize the semantic relationships between different topics, providing a holistic view of the topic space and facilitating the identification of topic clusters and overarching themes within the corpus.

Fig: 8 Word Cloud Visualization

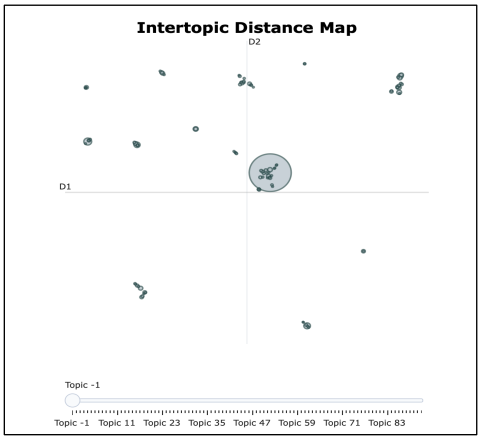

Fig: 9 Intertopic Distance Map

The flowchart outlines the steps involved in comparing four topic modeling algorithms on a dataset of New York Times articles. All methods begin with preprocessing the text data (tokenization, stopword removal). Then, the paths diverge based on the chosen algorithm: LSA, LDA, BERT Topic, or NMF.

LSA and NMF require a predefined number of topics during training, while LDA automatically determines the optimal number based on the data. BERT Topic identifies topics automatically without user input. Each method employs evaluation techniques and visualizations to assess the quality and interpretability of the extracted topics. Finally, a comparison across all methods considers factors like interpretability, topic coherence, and insights from visualizations to determine the most effective approach for this specific dataset.

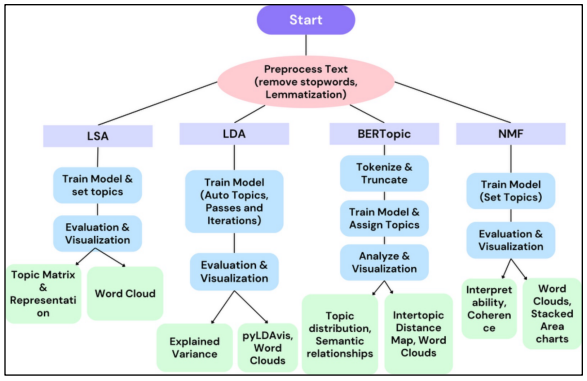

Fig: 10 Flow Chart for all Methods Used

RESULTS AND DISCUSSION

In the results obtained from Latent Semantic Analysis (LSA), the model effectively identified coherent topics within the text data, shedding light on underlying themes and concepts present in the corpus of documents. Through visualization techniques such as word clouds and bar plots, the top words contributing to each topic were vividly illustrated, aiding in interpretation. Analysis of the explained variance ratio provided valuable insights into determining the optimal number of topics for the model. Furthermore, the exploration of document relationships using cosine similarity matrices enhanced our understanding of clustering patterns within the corpus. Similarly, the LDA model successfully identified 30 coherent topics within the New York Times news articles dataset, offering comprehensive insights into the diverse themes discussed. Visualization techniques, including word clouds and topic-word importance heatmaps, facilitated interpretation, while the coherence score assessment affirmed the interpretability of the topics. Overall, both LSA and LDA models significantly contributed to a comprehensive analysis and interpretation of the dataset, providing valuable insights into its content and structure. Additionally, the adoption of BERTopic showcased its prowess as a powerful tool for topic modeling and text analysis, harnessing advanced NLP techniques to uncover meaningful insights from large volumes of text data. These findings underscore the effectiveness of topic modeling techniques in uncovering hidden themes and structuring textual data for further analysis and understanding.

CONCLUSION

In conclusion, the application of diverse topic modeling techniques, including Latent Semantic Analysis (LSA), Latent Dirichlet Allocation (LDA), and BERTopic, has demonstrated their efficacy in uncovering latent themes and

structuring textual data within the New York Times articles dataset. Through meticulous preprocessing, model training, and visualization, each approach provided valuable insights into the underlying content and structure of the dataset, facilitating comprehensive analysis and interpretation. These findings underscore the significance of topic modeling methodologies in uncovering hidden patterns and themes within textual data, thereby enabling deeper understanding and exploration of complex information landscapes. Moving forward, further refinement and exploration of these techniques hold promise for advancing our understanding of textual data and extracting meaningful insights across various domains.

FUTURE WORK

The realm of topic modeling for New York Times articles presents several promising avenues for exploration and refinement. Firstly, incorporating more advanced preprocessing techniques, such as sentiment analysis or named entity recognition, could enrich the understanding of the dataset by capturing nuances in language and identifying key entities mentioned in the articles. Additionally, exploring novel topic modeling algorithms or hybrid approaches that combine the strengths of multiple techniques could enhance the accuracy and interpretability of topic extraction, particularly in handling large and diverse text corpora. Furthermore, integrating domain-specific knowledge or external data sources, such as social media trends or user feedback, could provide additional context and enrich the topics identified, leading to more informed insights and recommendations. Lastly, conducting longitudinal studies to track topic evolution over time or across different sections of The New York Times could offer valuable insights into changing societal trends and news coverage patterns, facilitating a deeper understanding of media dynamics and audience interests. Overall, these potential future directions hold promise for advancing the field of topic modeling and enhancing our understanding of textual data within the context of news articles from The New York Times.

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