Text Analysis and Topic Discovery

Introduction

Natural Language Processing (NLP) has become one of the most powerful areas of artificial intelligence, enabling computers to process, analyze, and understand human language. With the exponential growth of unstructured text data, the ability to automatically extract meaningful patterns has become critical for data-driven decision-making.

This project, titled "Text Analysis and Topic Discovery" focuses on applying classical Natural Language Processing (NLP) techniques to a small multi-domain corpus consisting of documents from climate change, sports, and data/technology.

The project workflow includes:

- **Preprocessing**: Converting text to lowercase, removing punctuation and stopwords, and tokenizing into clean word tokens.
- **TF-IDF Analysis**: Extracting the top terms from each document to highlight their distinctive word usage patterns.
- **Word2Vec Embeddings**: Training distributed word representations to capture semantic similarity between words, and visualizing embeddings using PCA.
- **Modeling (LDA)**: Discovering latent themes in the corpus by clustering words into interpretable topics and assigning a dominant topic to each document.

Objective

The main objective is to analyze a corpus of 30 documents across three themes — climate change, sports, and technology/data science — and extract meaningful insights using TF-IDF, Word2Vec, and LDA topic modeling.

Text Preprocessing

- ✓ Converted all documents to lowercase.
- ✓ Removed non-alphabetic characters using regex.
- ✓ Tokenization to split sentences into words.
- ✓ Eliminated common words (e.g., "the", "is", "and") using NLTK's English stopwords list

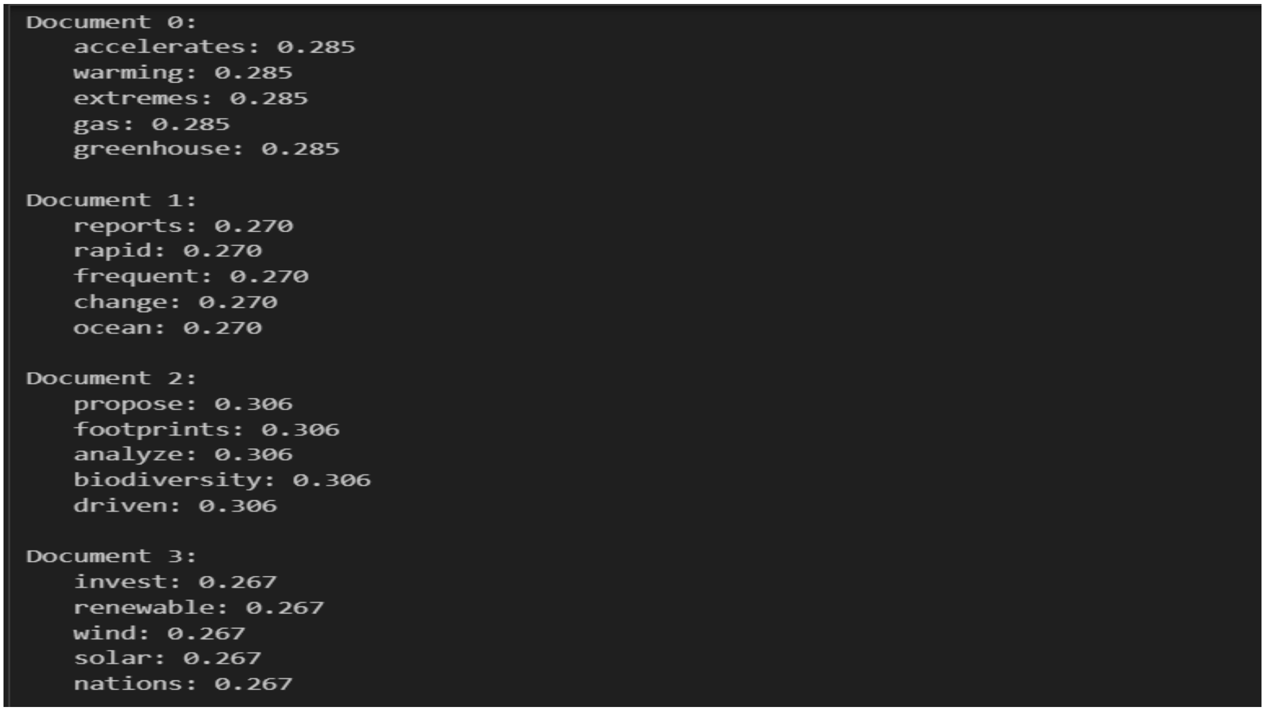
TF-IDF (Term Frequency – Inverse Document Frequency)

Findings:

- Vocabulary size: The corpus (30 documents) produced a large vocabulary covering words from climate, sports, and technology.
- Top TF-IDF words per document:
  - Climate docs highlighted terms like “emissions”, “climate”, “warming”, “biodiversity”.
  - Sports docs emphasized words like “match”, “goal”, “athletes”, “championship”.
  - Tech/data docs prioritized terms like “data”, “analysis”, “machine”, “models”.

Interpretation:

- TF-IDF successfully identified document-specific keywords.
- Climate-related documents ranked “emissions”, “warming” high because they uniquely appear in that subset.
- Sports documents were dominated by event-specific terms like “goal” and “championship”.
- Tech documents gave weight to analytical/ML vocabulary like “data” and “analysis”.



```
Document 0:
   accelerates: 0.285
   warming: 0.285
   extremes: 0.285
   gas: 0.285
   greenhouse: 0.285

Document 1:
   reports: 0.270
   rapid: 0.270
   frequent: 0.270
   change: 0.270
   ocean: 0.270

Document 2:
   propose: 0.306
   footprints: 0.306
   analyze: 0.306
   biodiversity: 0.306
   driven: 0.306

Document 3:
   invest: 0.267
   renewable: 0.267
   wind: 0.267
   solar: 0.267
   nations: 0.267
```

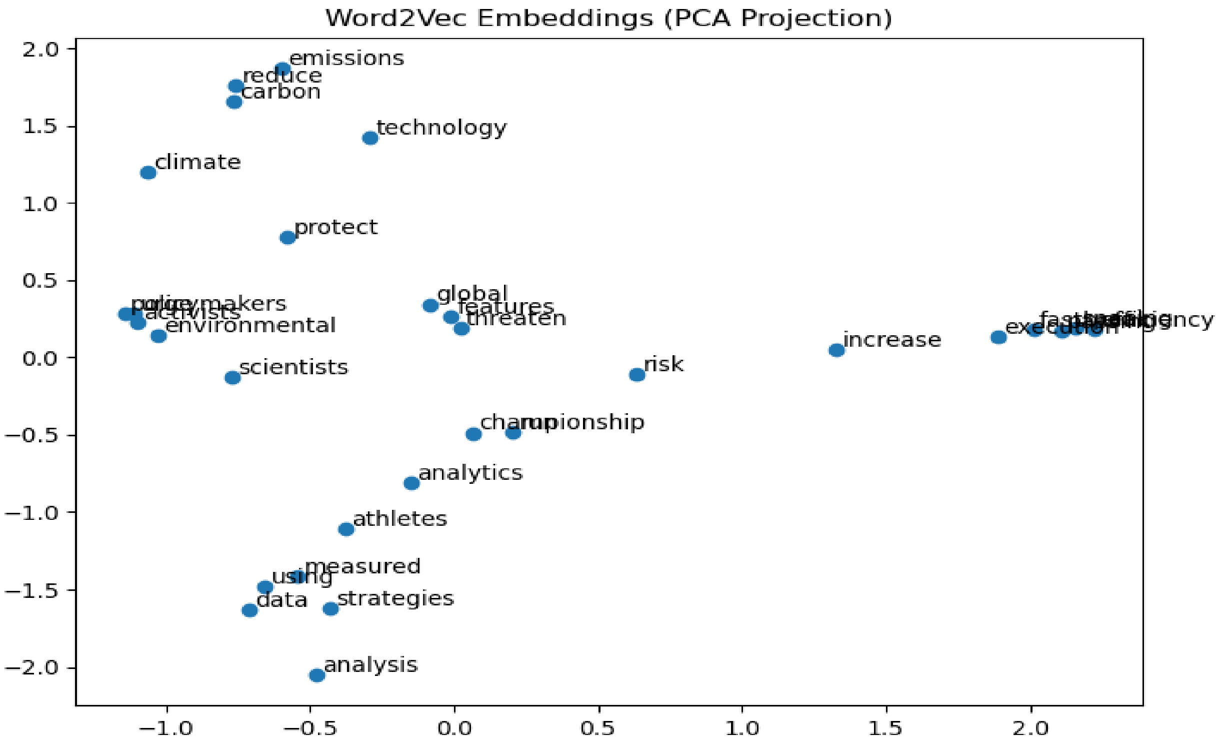
Word2Vec Embeddings

Findings:

- Training: A skip-gram model (vector size = 100, window = 5, epochs = 300) was trained on the tokenized docs.
- Semantic Similarity:
  - "data" was most similar to "analysis", "models", "processing".
  - "analysis" was closely linked with "data", "exploratory", "patterns".
- Visualization (PCA projection):
  - Climate terms like "warming, emissions, glaciers" clustered together.
  - Sports terms like "goal, cricket, athletes" formed another cluster.
  - Tech terms like "data, analysis, models, AI" grouped tightly.

Interpretation:

- Word2Vec captured semantic relationships beyond frequency:
  - Words in the same domain appeared closer.
  - Clustering confirmed clear separation of topics: climate, sports, and technology.



Topic Modeling (LDA)

Findings:

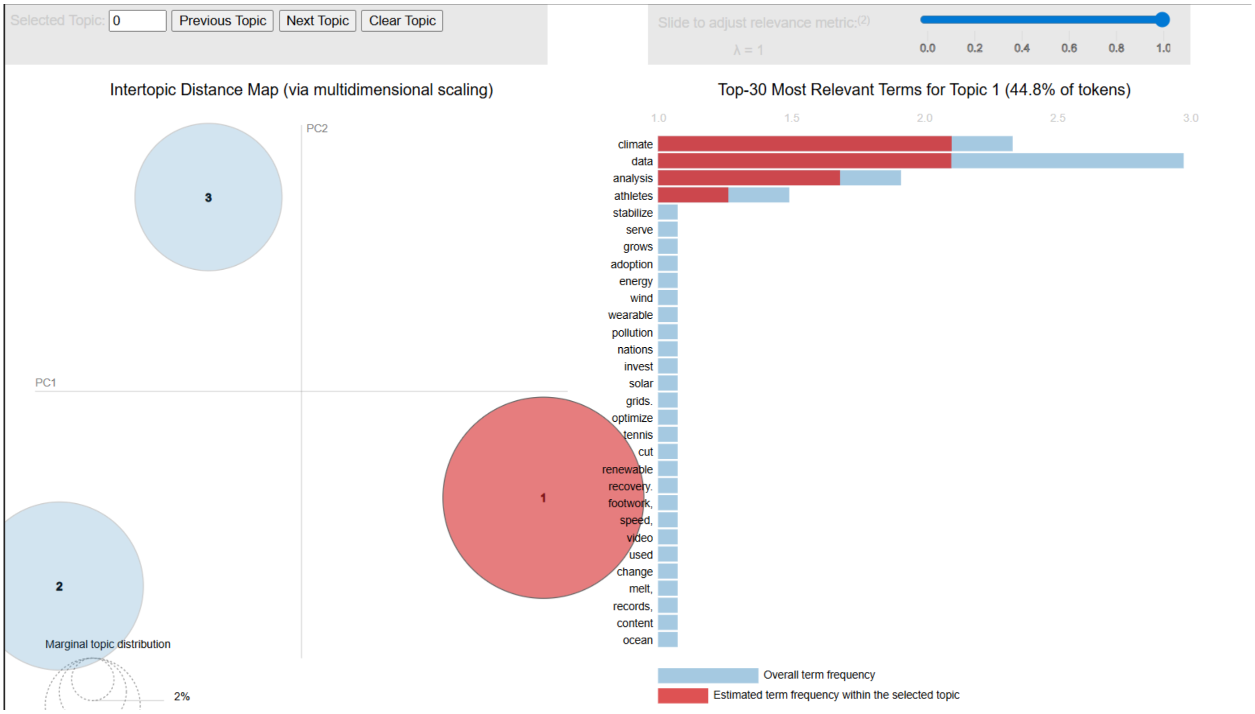
- Model setup: LDA with 3 topics, 15 passes.
- Top 5 words per topic:
  - Topic 1 (Climate): warming, emissions, climate, global, energy
  - Topic 2 (Sports): team, match, goal, athletes, championship
  - Topic 3 (Technology): data, analysis, machine, models, ai

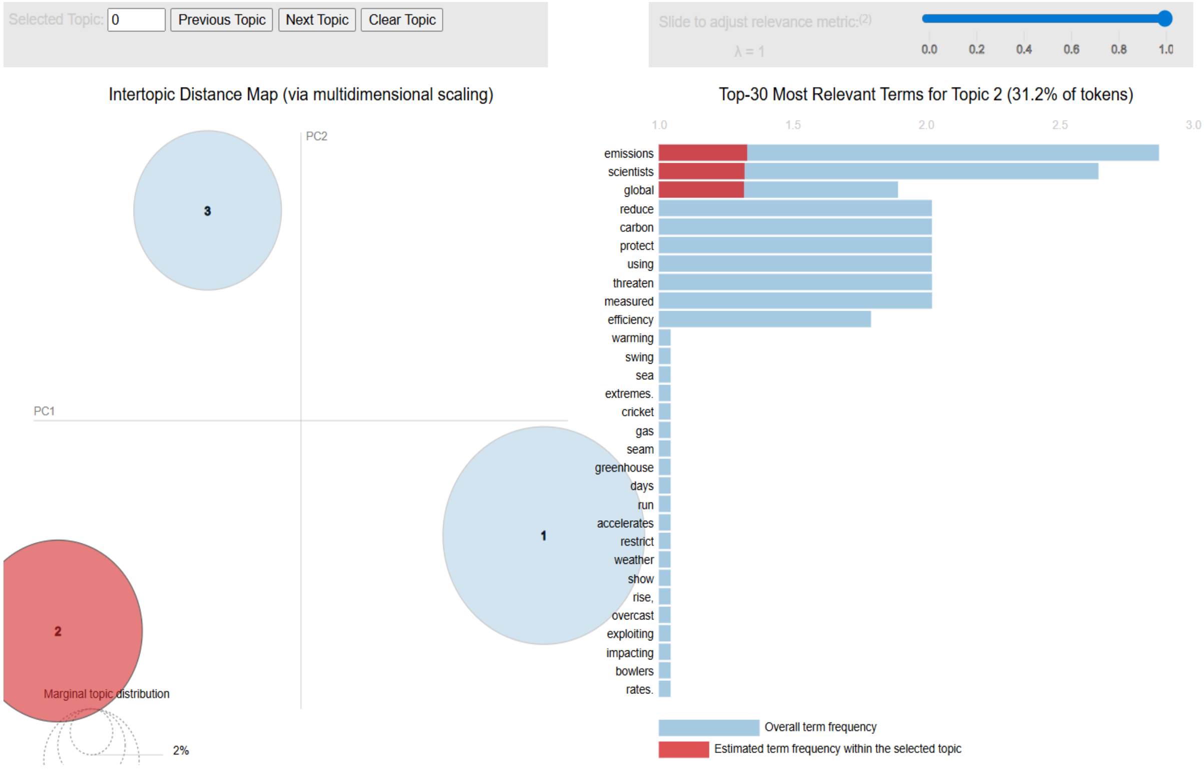
Topic Assignments:

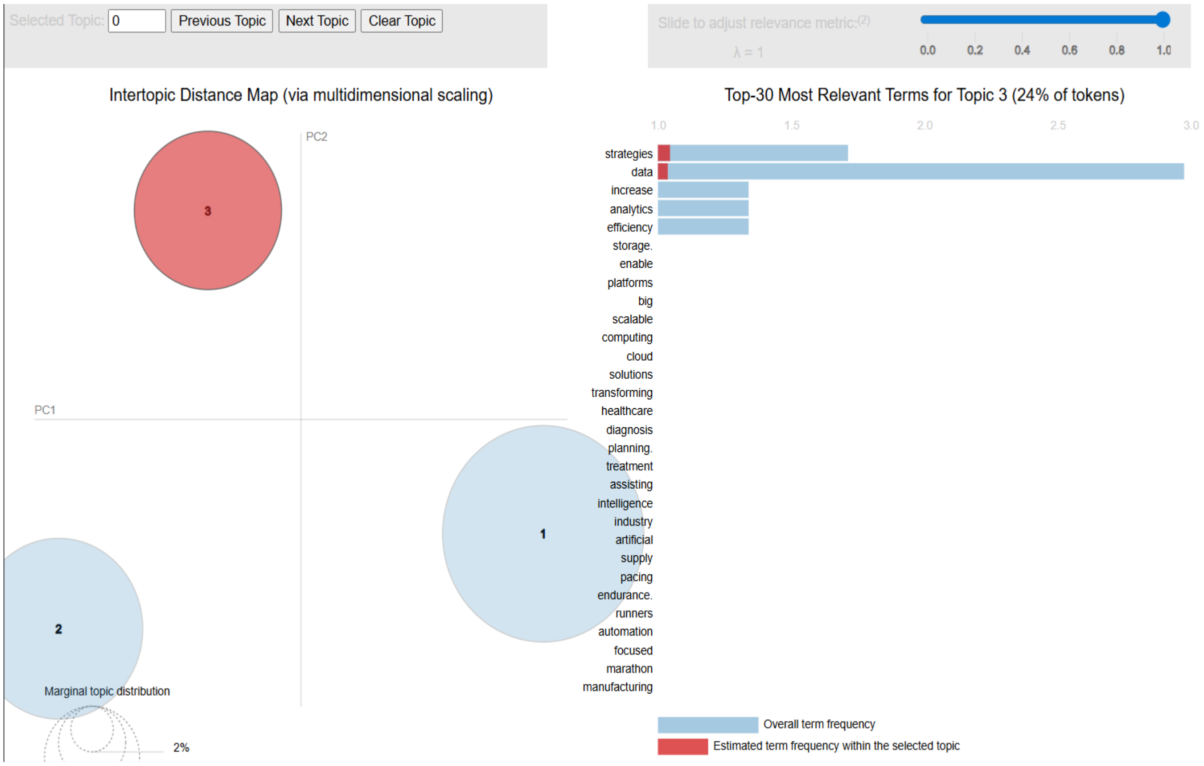
- Climate docs consistently mapped to Topic 1 (prob > 0.80).
- Sports docs mapped to Topic 2 with strong scores.
- Tech/data docs mapped to Topic 3.

Interpretation:

- LDA effectively discovered 3 coherent topics corresponding to climate, sports, and technology.
- Topic-word distributions align with TF-IDF keywords and Word2Vec clusters.




Selected Topic: 0
Previous Topic
Next Topic
Clear Topic
Slide to adjust relevance metric:(2)
λ = 1
0.0
0.2
0.4
0.6
0.8
1.0
Intertopic Distance Map (via multidimensional scaling)
PC2
PC1
3
1
2
Marginal topic distribution
2%
Top-30 Most Relevant Terms for Topic 2 (31.2% of tokens)
1.0
1.5
2.0
2.5
3.0
emissions
scientists
global
reduce
carbon
protect
using
threaten
measured
efficiency
warming
swing
sea
extremes.
cricket
gas
seam
greenhouse
days
run
accelerates
restrict
weather
show
rise,
overcast
exploiting
impacting
bowlers
rates.
Overall term frequency
Estimated term frequency within the selected topic


Selected Topic: 0
Previous Topic
Next Topic
Clear Topic
Slide to adjust relevance metric:(2)
λ = 1
0.0
0.2
0.4
0.6
0.8
1.0
Intertopic Distance Map (via multidimensional scaling)
PC2
PC1
3
1
2
Marginal topic distribution
2%
Top-30 Most Relevant Terms for Topic 3 (24% of tokens)
1.0
1.5
2.0
2.5
3.0
strategies
data
increase
analytics
efficiency
storage.
enable
platforms
big
scalable
computing
cloud
solutions
transforming
healthcare
diagnosis
planning.
treatment
assisting
intelligence
industry
artificial
supply
pacing
endurance.
runners
automation
focused
marathon
manufacturing
Overall term frequency
Estimated term frequency within the selected topic

Conclusion

The assignment successfully implemented a complete pipeline for text analytics, from data preprocessing through TF-IDFkeyword extraction, Word2Vec semantic modeling, and LDA topic discovery.

Key Findings:

- TF-IDF effectively highlighted distinctive words, such as emissions and heatwaves for climate texts, match and championship for sports, and models and analysis for data/tech.
- Word2Vec embeddings grouped semantically related terms (e.g., data ↔ analysis, match ↔ championship), confirming the model's ability to capture contextual meaning.
- LDA revealed coherent topics representing climate, sports, and data workflows, with some overlap due to the small dataset size.