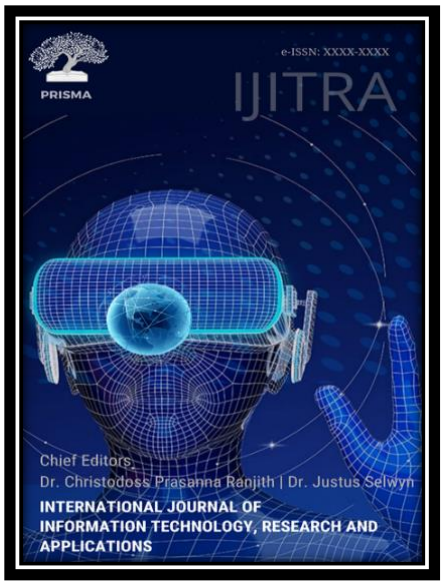

International Journal of Information Technology, Research and Applications (IJITRA)

Merlin F, Devi Vaishnavi M, Divyabharathi L, Sri Nithi Murali, Tarun V (2024). AI-Driven Sentiment Classification via Combinatorial Techniques and Reasoning, 3(4), 50-56.

ISSN: 2583-5343

DOI: 10.59461/ijitra.v3i4.121

The online version of this article can be found at:
https://www.ijitra.com/index.php/ijitra/issue/archive

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AI-Driven Sentiment Classification via Combinatorial Techniques and Reasoning

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Article Info

Article history:

Received November 02, 2024
Revised December 10, 2024
Accepted December 15, 2024

Keywords:

Sentiment analysis
Permutation
AI Logics
Fuzzy Logic

ABSTRACT

This paper proposes an AI-driven approach to sentiment analysis, leveraging mathematical concepts such as permutations, along with logical reasoning techniques. The method involves splitting the text; permutations are used to extract n-grams. AI-driven logic is then applied for feature scoring. Finally, fuzzy logic integrates these scores to classify sentiments. This approach focuses on enhancing sentiment classification accuracy by blending AI-based features.

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1. INTRODUCTION

1.1 Background

Sentiment analysis is a crucial task in natural language processing (NLP) that enables organizations to analyze opinions, feedback, and social media trends. Traditional approaches rely on lexicon models or machine learning methods to classify text as positive, negative, or neutral. However, these methods often struggle with subtle verbal nuances and ambiguity inherent in human language. As textual data continues to grow in complexity, there is a pressing need for effective sentiment interpretation.

1.2 Problem Statement

Existing sentiment analysis methods struggle to capture contextual variability and overlapping emotional expressions in text. For example, a sentence like "I'm disappointed, but not surprised" demands nuanced reasoning that integrates context, semantics, and tone. This limitation underscores the need for a sentiment analysis methodology that utilizes flexible and interpretable reasoning, powered by AI-driven features.

1.3 Literature Review

Customer reviews are crucial in e-commerce for understanding sentiments and improving products. While text reviews provide insights, speech reviews capture richer emotions. Using Natural Language Processing (NLP), speech-to-text conversion enables sentiment analysis, classifying feedback as positive, negative, or

neutral. Fuzzy logic enhances this process by handling ambiguity, offering nuanced classifications. This approach helps businesses refine products and improve customer satisfaction effectively.[1][3]

AI has significantly advanced mathematics by assisting in theorem proving and solving complex problems. Techniques like reinforcement learning, symbolic computation, genetic programming, and large language models enable AI systems to explore mathematical spaces and identify novel patterns. Paradigms such as AlphaZero analyze mathematical texts to extract concepts and strategies. Key advancements include aiding intuition in conjectures, optimizing combinatorial problems, proving geometric theorems, and discovering efficient algorithms for tasks like matrix multiplication and sorting, demonstrating AI's transformative potential in mathematical discovery.[2]

Social media serves as a valuable platform for sharing information about products and services in e-commerce. Customers frequently provide feedback on product features and specifications through reviews on platforms like Twitter and Flipkart. This study focuses on aspect-based sentiment analysis of such reviews to identify issues and opinions about product quality. By employing Natural Language Processing (NLP) and fuzzy logic, the proposed system automates the extraction of semantic aspects and assigns weightage to various comments. [7] Real-time data from Twitter and Flipkart were used for experimentation, demonstrating that this approach effectively analyzes customer opinions. The system retrieves hidden insights about product specifications, providing concise information to aid customers in making informed purchasing decisions. Additionally, it assists businesses in refining their offerings based on customer expectations and feedback, thereby improving their competitive edge in the market[4]

Formal logical approach for deep structural analysis of syntactical properties in texts, utilizing machine learning techniques for efficient syntactical tagging. Unlike traditional machine learning methods, which often focus on sentence or word-level sentiment analysis and struggle with capturing long-distance dependencies, the proposed method applies entity-level sentiment analysis. By analyzing the syntactical structure more deeply, this approach enhances the ability to understand and interpret complex textual relationships, offering a promising alternative to existing sentiment analysis techniques.[5]

1.4 Proposed Approach

This paper presents a novel sentiment analysis framework that integrates three key components:

1. Permutations: To generate informative n-grams capturing word relationships.

2. AI-Based Feature Scoring: Utilizing contextual embeddings and other models for precise sentiment evaluation.

3. Fuzzy Logic: To aggregate feature scores and address ambiguity in sentiment classification.

From the tokenized set of words the n-grams are extracted which will be useful for extracting features from the set. Then the AI model evaluates and score the features, then fuzzy logic is used for handlind uncertainty in complex sentences.

2. METHOD

2.1 Research Design

The proposed sentiment analysis framework integrates feature extraction, AI-based scoring, and fuzzy logic for robust and interpretable sentiment classification. The research design consists of the following stages:

1. Text Preprocessing: Tokenization and preparation of textual data for analysis.

2. N-Gram Extraction: Utilizing combinations to generate features representing sequential patterns.

3. AI-Based Feature Scoring: Assigning sentiment scores to features using advanced AI models.

4. Fuzzy Logic-Based Sentiment Aggregation: Combining individual feature scores into a final sentiment classification.

2.2 Research Procedure

The step-by-step procedure is outlined as follows:

Step 1: Text Preprocessing

- Tokenzie the input text into individual words, ensuring that stop words and punctuations are properly handled.
- Example:
  Input: “I love to read books.”
  Output: {I, love, to, read, books}

Step 2: N-Gram Extraction using Permutation

- Generate n-gram to capture contextual relationships between words.
- Example for n = 2:
  Tokens = {I, love, to, read, books}
  Bigrams = {I love, love to, to read, read books} ,etc

Step 3: AI-Based Feature Scoring

- Using AI models to evaluate the sentiment of each feature.
- Assign score for positive ($S_{positive}$), neutral($S_{neutral}$), and negative($S_{negative}$) sentiment categories.
- Example:
  “Love”
  Positive score = 0.9, Neutral score = 0.1, Negative score = 0.0

Step 4: Fuzzy Logic-Based Aggregation

- Define membership functions for each sentiment category.
- Aggregate score across all features using fuzzy rules to calculate final sentiment.

Step 5: Output

- Classify the text based on the score

2.3 Algorithm

```
def sentiment_analysis(text, n):

    # Step 1: Preprocess text

    tokens = tokenize(text)

    # Step 2: Generate n-grams

    n_grams = generate_ngrams(tokens, n)

    # Step 3: Score features using AI

    positive_scores = []

    neutral_scores = []

    negative_scores = []

    for feature in features:
```

```
        pos, neu, neg = ai_score(feature)  # AI model for scoring
        positive_scores.append(pos)
        neutral_scores.append(neu)
        negative_scores.append(neg)
    # Step 4: Apply fuzzy logic
    pos_membership = fuzzy_membership(positive_scores, "positive")
    neu_membership = fuzzy_membership(neutral_scores, "neutral")
    neg_membership = fuzzy_membership(negative_scores, "negative")
    # Step 5: Aggregate scores
    if pos_membership > neu_membership and pos_membership > neg_membership:
        sentiment = "Positive"
    elif neg_membership > pos_membership and neg_membership > neu_membership:
        sentiment = "Negative"
    else:
        sentiment = "Neutral"
    return sentiment
```

3. RESULTS AND DISCUSSION

3.1 Results

The results of the sentiment analysis framework are illustrated through experiments conducted on sample datasets. Key findings and evaluations include:

1. **Performance on Sample Texts:**
   Text 1:
   "I Love This Amazing New Restaurant!"

   Step 1: Splitting Text Into Words
   Tokenized Set: {I, Love, This, Amazing, New, Restaurant}

   Step 2: N-gram Extraction Using Permutations
   For Bigrams (N = 2), Possible Permutations Include:

   (I, Love), (Love, I), (Love, This), (This, Love), (Amazing, New), (New, Restaurant), Etc.

   Step 3: Feature Extraction Using AI
   For Size 2:

   {Love, Amazing}, {Amazing, Restaurant}, {New, Restaurant}, Etc.

   Step 4: Scoring Features Using AI Logic
   Using Sentiment Lexicons And Contextual Ai Logic, The Extracted Features Are Scored:

"Love": Positive: 0.95, Neutral: 0.05, Negative: 0.0
"Amazing": Positive: 0.9, Neutral: 0.1, Negative: 0.0
"New Restaurant": Positive: 0.8, Neutral: 0.15, Negative: 0.05

Step 5: Fuzzy Logic For Sentiment Integration
Fuzzy Logic Consolidates Scores For Final Sentiment Classification:

Positive Membership: 0.9
Neutral Membership: 0.1
Negative Membership: 0.0
Conclusion: The Sentiment Is Overwhelmingly Positive.

Text 2:

"I'm Disappointed, But Not Surprised, That The New Movie Didn't Live Up To The Hype."

Step 1: Splitting Text Into Words

Tokenized Set: {I, Disappointed, But, Not, Surprised, New, Movie, Didn’t, Live, Up, Hype}

Step 2: N-gram Extraction Using Permutations

For Bigrams (N = 2), Possible Permutations Include:

(Disappointed, Surprised), (New, Movie), (Movie, Hype), Etc.

Step 3: Feature Extraction Using AI

For Size 2:

{Disappointed, Movie}, {Not, Surprised}, {Live, Hype}, Etc.

Step 4: Scoring Features Using Ai Logic

Using Ai-driven Sentiment Scoring:

"Disappointed": Positive: 0.0, Neutral: 0.1, Negative: 0.9

"Not Surprised": Positive: 0.1, Neutral: 0.5, Negative: 0.4

"New Movie": Positive: 0.5, Neutral: 0.3, Negative: 0.2

Step 5: Fuzzy Logic For Sentiment Integration

Fuzzy Logic Combines Scores:

Positive Membership: 0.2

Neutral Membership: 0.3

Negative Membership: 0.8

Conclusion: The Sentiment Is Primarily Negative, With Slight Neutral Undertones.

a. Fuzzy Logic-Based Sentiment Analysis

The fuzzy logic algorithm played a critical role in aggregating feature-level scores into meaningful sentiment classifications. The detailed steps are:

Algorithm: Fuzzy Logic-Based Sentiment Analysis
Input: Scores for Positive, Neutral, and Negative sentiment for all features.
Output: Final sentiment classification (Positive, Neutral, Negative).

Algortihm:

1. Define the membership functions.
2. Aggregate the membership values.
3. Compare membership values to determine the dominant sentiment.

3.3 Discussion

The integration of mathematical concepts like combinatorics helps to evaluate all possible permuations and with the help of fuzzy logic enables the framework to handle uncertainty effectively.

4. CONCLUSION

This paper prsents a sentiment analysis approach combining AI-based feature scoring with fuzzy logic for flexible reasoning. The method demonstrates that how mathematical concepts ccombined with AI techinques can improve the analysis, making it suitable for diverse application such as social media analysis and feedback processing

ACKNOWLEDGEMENTS

Author thanks all individuals whose work has contributed to this paper.

FUNDING INFORMATION

This research was conducted without any external funding or financial support.

REFERENCES

[1] Jayashree, D., Pandithurai, O., Prasad, S., Suresh, A. S., & Vigneshwaran, S. (2021, October 8). Sentimental analysis on voice based reviews using fuzzy logic. *2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA)*. Presented at the 2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA), Coimbatore, India. doi:10.1109/icaeca52838.2021.9675713
[2] Miao, Q., & Wang, F.-Y. (2024). AI for mathematics. In *SpringerBriefs in Service Science* (pp. 21–39). doi:10.1007/978-3-031-67419-8_2
[3] Krishnaveni Veeranan, Pandian , V., Thamaraiselvi, & Antonyraj Martin. (2024). Impact of Mathematical Models in IT System Design and Optimization. International Journal of Information Technology, Research and Applications, 3(1), 1–11. https://doi.org/10.59461/ijitra.v3i1.83
[4] Maheswari, S. U., & Dhenakaran, S. S. (2020, July). Aspect based fuzzy logic sentiment analysis on social media big data. *2020 International Conference on Communication and Signal Processing (ICCSP)*. Presented at the 2020 International Conference on Communication and Signal Processing (ICCSP), Chennai, India. doi:10.1109/iccsp48568.2020.9182174
[5] Petersen, N. C., & Villadsen, J. (2014). Combining formal logic and machine learning for sentiment analysis. In *Lecture Notes in Computer Science*. *Lecture Notes in Computer Science* (pp. 375–384). doi:10.1007/978-3-319-08326-1_38
[6] Kumar, H. M. K., & Harish, B. S. (2019). A new feature selection method for sentiment analysis in short text. *Journal of Intelligent Systems*, *29*(1), 1122–1134. doi:10.1515/jisys-2018-0171
[7] Martin, A. (2022). Mari's Algorithm to Solve a Fuzzy Transportation Problem by Using Trapezoidal Fuzzy Number. International Journal of Information Technology, Research and Applications, 1(2), 16–22. https://doi.org/10.5281/zenodo.7008969

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