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DeepSarcasm: A BiLSTM and GloVe Powered Model for Identifying Sarcasm in Context

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Abstract: This project explores the intricate challenge of sarcasm detection in textual data using advanced Natural Language Processing (NLP) techniques. The primary goal is to create a model capable of accurately identifying and classifying sarcastic remarks within various contexts. We address this by leveraging Bidirectional Long Short-Term Memory (BiLSTM) networks, known for their ability to understand context by processing data in both forward and backward directions. To enhance semantic understanding, GloVe embeddings are employed to capture word relationships and contextual nuances. Our methodology encompasses comprehensive data preprocessing steps - such as tokenization, stopword removal, and lemmatization - to ensure clean and coherent text input. The BiLSTM model is trained on a diverse dataset that includes both sarcastic and non-sarcastic text samples, facilitating the learning of distinctive patterns. We evaluate the model's performance using metrics like accuracy, precision, recall, and F1-score, anticipating that our model will effectively discern subtle sarcastic cues and outperform baseline methods. This study's results have significant implications for sentiment analysis, social media monitoring, and conversational AI systems. Future directions include extending the model to handle multilingual sarcasm detection, integrating real-time data processing, and addressing ethical considerations in practical applications.

Keywords: *NLP, Sarcasm Detection, BiLSTM, GloVe embeddings.*

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I. INTRODUCTION

The project focuses on sarcasm detection using a high-quality news headlines dataset. Sarcasm detection is a challenging task in natural language processing (NLP) due to its nuanced and context-dependent nature. By leveraging a dataset with formal language and high-quality labels, the project aims to develop effective machine learning models for identifying sarcasm in news headlines.

The problem statement revolves around the difficulty of accurately detecting sarcasm, especially in textual data such as news headlines. Existing datasets, particularly those from social media platforms like Twitter, often contain noisy labels and informal language, making sarcasm detection less reliable.

The project aims to address this challenge by utilizing a curated dataset specifically designed for sarcasm detection in news headlines.

The objectives of the project include - developing machine learning models capable of accurately detecting sarcasm in news headlines, evaluating the performance of sarcasm detection models using appropriate metrics, comparing the effectiveness of different machine learning algorithms and techniques for sarcasm detection and enhancing the understanding of sarcasm detection challenges and techniques through empirical experiments.

II. RELATED WORK

A. Desired Outcomes and Scope of the project

The desired outcomes include - achieving high accuracy in sarcasm detection, surpassing baseline models, identifying the most effective machine learning algorithm or technique for sarcasm detection in news headlines, publishing research findings and contributing to the advancement of sarcasm detection techniques in NLP.

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The project's scope includes - developing and training machine learning models for sarcasm detection, evaluating model performance using metrics such as accuracy, precision, recall, and F1 score, analyzing the impact of different feature engineering approaches and model architectures on sarcasm detection accuracy, targeting news headlines from reputable sources to ensure data quality and relevance.

B. Literature Review

- *"Sarcasm Over Time and Across Platforms: Does the Way We Express Sarcasm Change?" (Mondher Bouazizi, Tomoaki Ohtsuki, .., 2022):*

- Summary: The paper investigates the dynamics of sarcasm expression across different platforms (Twitter, Reddit, news websites) and over time. It aims to provide a comprehensive understanding of sarcasm detection in digital communication and its impact on sentiment analysis. The authors analyze data from three diverse platforms, highlighting variations in how sarcasm is employed based on language mastery, user demographics, and platform-specific characteristics. They confirm sarcasm's role as a polarity switcher in text analysis, altering sentiment polarity significantly. The study emphasizes the importance of platform-specific nuances in sarcasm detection algorithms for accurate sentiment analysis outcomes.

- *"Sarcasm Detection Using Deep Learning With Contextual Features" (Md Saifullah Razali, Alfian Abdul Halin, Lei Ye, Shyamala Doraisamy, Noris Mohd Norowi, .., 2021):*

- Summary: The paper focuses on detecting sarcasm in tweets using deep learning extracted features combined with contextual handcrafted features. It aims to identify the most optimal features by extracting a feature set from a Convolutional Neural Network (CNN) architecture and combining it with carefully handcrafted feature sets designed specifically for sarcasm detection. The authors conduct experiments using various machine learning techniques for classification and find Logistic Regression to be the best algorithm for this task, achieving positive results in terms of Accuracy, Precision, Recall, and F1-measure. The study also compares its results with recent works and evaluates the performance of each feature set, demonstrating valuable insights into tweet feature usage and the development of a framework for sarcasm detection that significantly improves F1-measure compared to existing studies using the same dataset. Additionally, the paper suggests future work involving the use of multiple datasets for broader comparisons and expanding the process of extracting meaningful features to further enhance sarcasm detection capabilities.

- *"Sarcasm Detection of Textual Data on Online Social Media: A Review" (Aruna Bhat, Govind Narayan Jha, .., 2022):*

- Summary: This paper refers to the sarcasm detection process and approaches and comparison of results on various models and datasets. Sarcasm refers to the phrases which indicate the opposite meaning of what it actually wants to express. In recent years the NLP has become a very interesting topic for the researchers. Sarcasm detection is also part of NLP. Sarcasm detection is somewhat similar to sentiment analysis which mathematically illustrates and categorizes the polarity of a piece of text or phrase and determines whether it is sarcastic or not. In recent years sarcasm detection was performed on twitter datasets, reddit corpus, SARC dataset and many more. Main focus of this paper is on various ML and deep learning approaches to sarcasm detection like Support Vector Machine, Convolution Neural network, LSTM models used for sarcasm detection in recent research. In our study we will explore various approaches to sarcasm detection. At the end I will compare and contrast the different approaches for sarcasm detection based on their accuracy.

III. RESEARCH METHODOLOGY

A. Data Collection Process

- Data Collection: Collected labeled datasets from diverse sources like social media, news articles, and online content, encompassing instances of both sarcastic and non-sarcastic statements.

- Data Preprocessing: Conducted extensive data cleaning, including tokenization, stemming, and stop word removal. Special focus was given to adapting language nuances for workplace-specific expressions.

- Feature Extraction: Leveraged NLP techniques to extract relevant features from text. Employed methods like TF-IDF, word embeddings, and contextual embeddings to capture the intricacies of sarcasm.

- Model Selection: Choose a hybrid approach, integrating Convolutional Neural Networks (CNNs) for local pattern recognition and Long Short-Term Memory networks (LSTMs) for capturing contextual dependencies. This combination aims to enhance the model's ability to discern sarcasm in varied workplace contexts.

- Model Training: Conducted model training on the preprocessed and labeled sarcasm dataset. The process included rigorous validation to optimize parameters for workplace-specific sarcasm detection.

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- Performance Metrics: Evaluated the model using performance metrics such as accuracy, precision, recall, and F1 score on a separate test set. This step ensured an understanding of how well the model generalizes to new workplace sarcasm instances.

- Fine-Tuning: Adjusted model parameters based on evaluation results, iterating through the training process to enhance predictive accuracy and minimize false positives/negatives.

- Integration into Workplace Tools: Deployed the trained model for real-world use, integrating it into workplace communication tools for real-time sarcasm detection. Considered the development of a user interface for user-friendly interaction.

- User Feedback Loop: Established a mechanism for collecting user feedback on model predictions to continuously improve and refine the sarcasm detection system in the workplace setting.

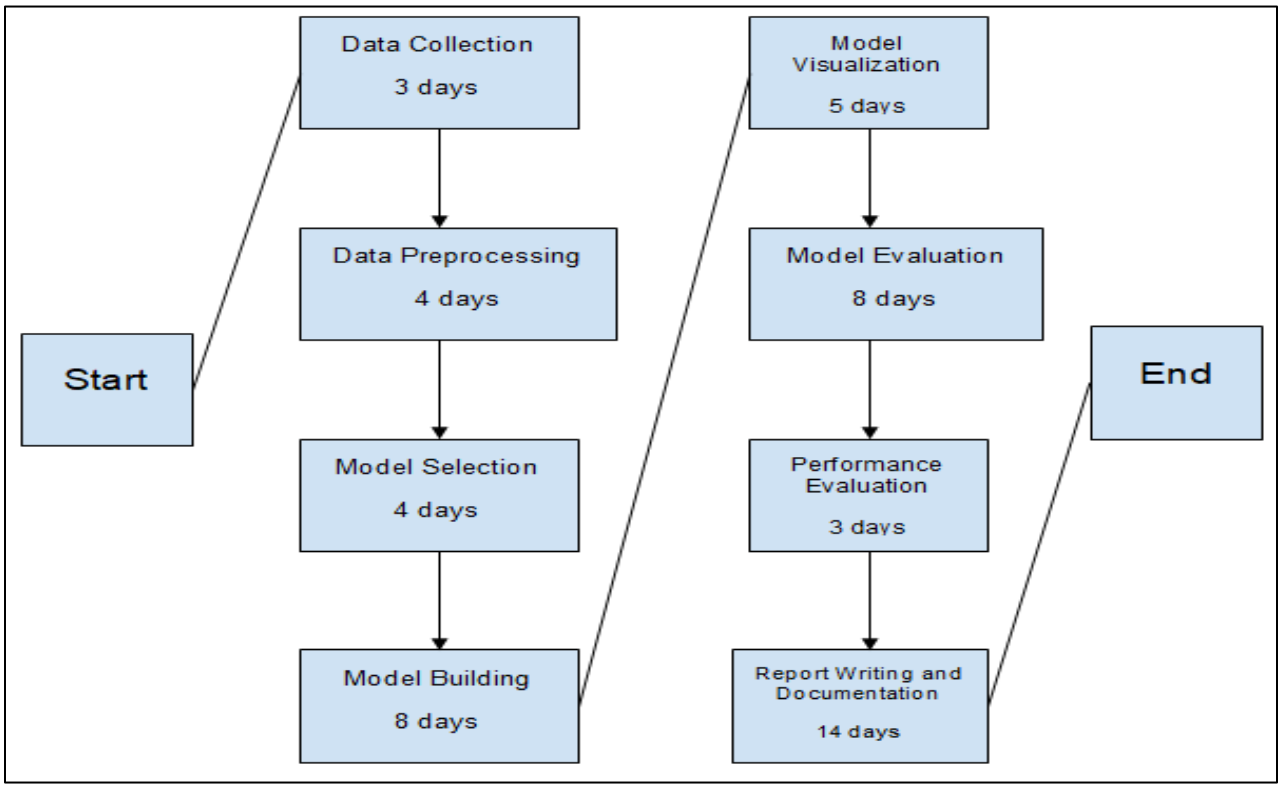

Fig. 1 - PERT Chart

B. Algorithms

- Bidirectional Long Short-Term Memory (BiLSTM): LSTM is a type of recurrent neural network (RNN) architecture that is particularly effective in capturing long-range dependencies in sequential data. It addresses the vanishing gradient problem of traditional RNNs by introducing gated mechanisms, such as forget gates, input gates, and output gates. These gates control the flow of information through the network, allowing LSTM models to retain and utilize relevant information over extended time steps. In this project, Bidirectional LSTM is utilized, which processes input sequences both forward and backward, enhancing the model's ability to capture context from both past and future tokens in the input.

- Bidirectional Encoder Representations from Transformers (BERT): BERT is a transformer-based language model developed by Google. It is designed to generate deep contextualized word representations by pre-training on a large corpora of text. BERT's architecture includes attention mechanisms that enable it to capture dependencies and relationships between words in a bidirectional manner. This bidirectional context understanding contributes significantly to tasks like sarcasm detection, where understanding the context and nuances of language is crucial for accurate classification. The BERT model used in this project is fine-tuned specifically for sarcasm detection tasks, leveraging its pre-trained knowledge to enhance the model's performance.

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C. Constraints / Limitations

- Data Bias: The effectiveness of the model is contingent on the diversity and representativeness of the training data. If the data is biased or lacks certain linguistic nuances, the model's performance may be limited.

- Contextual Sensitivity: The model may struggle with sarcasm heavily dependent on context or cultural references. The current implementation prioritizes broader context understanding, but improvements can be made to handle highly contextual instances.

- Overfitting: Due to the complexity of the model, there is a risk of overfitting to the training data. Regularization techniques and careful hyperparameter tuning are employed to mitigate this issue.

In conclusion, the presented sarcasm detection model represents a significant stride toward improving workplace communication dynamics. Its success in decoding sarcasm, coupled with the outlined future enhancements, positions the model as a versatile tool for addressing the nuanced challenges of modern workplace interactions. As workplaces evolve and incorporate diverse communication channels, the model's adaptability and continuous development underscore its potential to foster more effective and understanding professional relationships. This venture into multimodal learning, real-time implementation, and the integration of voice data exemplifies the commitment to staying at the forefront of technological advancements, ensuring that the sarcasm detection model remains a valuable asset in the evolving landscape of workplace communication.

D. Future Scope for Modification

- Fine-Tuning for Workplace Jargon: Future enhancements could involve refining the model to accommodate domain-specific language and industry-specific jargon. This fine-tuning process aims to enhance the model's accuracy in deciphering sarcasm within the nuanced language commonly employed in workplace contexts.

- Real-Time Implementation: Exploring real-time sarcasm detection in workplace communication tools stands as an exciting prospect for development. Enabling the model to provide instantaneous insights during live interactions could significantly impact communication dynamics, fostering a more dynamic and responsive workplace environment.

- Multimodal Learning: Workplace communication often incorporates multimedia content, making it beneficial to integrate visual and contextual cues into the sarcasm detection model. Future iterations might explore the incorporation of image or video data alongside textual information, allowing the model to analyze a broader range of communication modalities for improved sarcasm detection accuracy.

- Integration of Voice Data: Another avenue for future development involves extending the model to include voice data. Recognizing the significance of tone in conveying sarcasm, integrating audio analysis could offer valuable insights into the speaker's intonation, pitch, and overall vocal characteristics. This multimodal approach, combining both text and voice data, seeks to capture a more holistic understanding of sarcasm in workplace communication, refining the model's capacity to navigate the intricacies of spoken interactions.

E. Hardware and Software Specifications

Hardware and software specifications refer to the detailed technical requirements and features of the physical and digital components involved in a system or project. These specifications are essential for ensuring that the hardware and software components work together seamlessly to meet the desired objectives of a project.

Table 1 - Hardware and Software Specifications

Component	Specification
Hardware	
Server/Workstation	High-performance server or workstation with multicore processor, ample RAM, and storage capacity
Data Storage	Sufficient storage space for storing and processing customer data
Software	
Operating System (OS)	Linux/Unix or Windows for server-side operations
Programming Language	Python for implementing sarcasm detection algorithms

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Data processing and Analysis	Pandas and NumPy libraries for data manipulation and analysis
Text Processing	NLTK or SpaCy for advanced text processing
Deep Learning Frameworks	Tensorflow or Pytorch for implementing deep learning models
Machine Learning Library	Scikit-learn for general machine learning tasks and preprocessing
Visualization	Matplotlib and Seaborn for data visualization and insights presentation
IDE	Jupyter Notebooks or any preferred IDE for code development and documentation

F. Objectives

- Develop Comprehensive Dataset: Curate and preprocess a diverse dataset from news headlines. Ensure the dataset encompasses various topics, communities, and user interactions to create a robust foundation for sarcasm detection.
- Implement Advanced NLP Techniques: Apply state-of-the-art NLP techniques, including sentiment analysis models, to extract sentiment polarity and emotion from user comments. Tailor these techniques to enhance the accuracy of sarcasm detection, considering the nuanced nature of sarcastic expressions.
- Evaluate and Refine Models: Assess the performance of sarcasm detection models using appropriate metrics. Iterate on the models to enhance accuracy, robustness, and adaptability across different types of discussions and communities on platforms like Reddit.
- Generate Insights and Visualizations: Derive meaningful insights from sarcasm detection results. Create visualizations to represent sarcasm patterns over time, across diverse communities, and in response to specific events or topics. Enhance the interpretability of results through graphical representations.
- Compare with Existing Approaches: Benchmark the developed sarcasm detection models against existing approaches in the field. Demonstrate improvements and advancements in capturing nuanced sarcasm in the social media context. Highlight the project's contribution to the evolving landscape of NLP.
- Explore Practical Applications: Investigate potential applications of sarcasm detection results in areas such as online content moderation, sentiment-aware chatbots, and improving user experiences on social media platforms.
- Documentation and Reporting: Compile a comprehensive report adhering to best practices in research and analysis. Document the methodology, findings, and implications of the project. Present clear insights into the potential impact of sarcasm detection in online communication and user engagement.

G. System Design

➢ *Data Collection Module:*
- Responsible for gathering a diverse dataset of textual data containing both sarcastic and non-sarcastic content.
- Interfaces with data sources such as social media platforms, news articles, or custom datasets.

➢ *Data Preprocessing Module:*
- Cleans and preprocesses the collected data to remove noise, normalize text, and tokenize sentences.
- Includes techniques like lowercasing, punctuation removal, and stop word removal.

➢ *Feature Extraction Module:*
- Extracts relevant features from preprocessed text data.
- Utilizes techniques such as word embeddings (e.g GloVe) or contextual embeddings (e.g., BERT embeddings) to represent words and sentences in a meaningful vector space.

➢ *Model Development Module:*
- Incorporates machine learning models for sarcasm detection, such as Long Short-Term Memory (BiLSTM) networks, Bidirectional Encoder Representations from Transformers (BERT).
- Trains and fine-tunes the models using the preprocessed data and extracted features.

➢ *Model Evaluation Module:*
- Evaluates the performance of trained models using standard evaluation metrics like accuracy, precision, recall, F1 score, and confusion matrix.
- Validates the models against a held-out test dataset to assess generalization.

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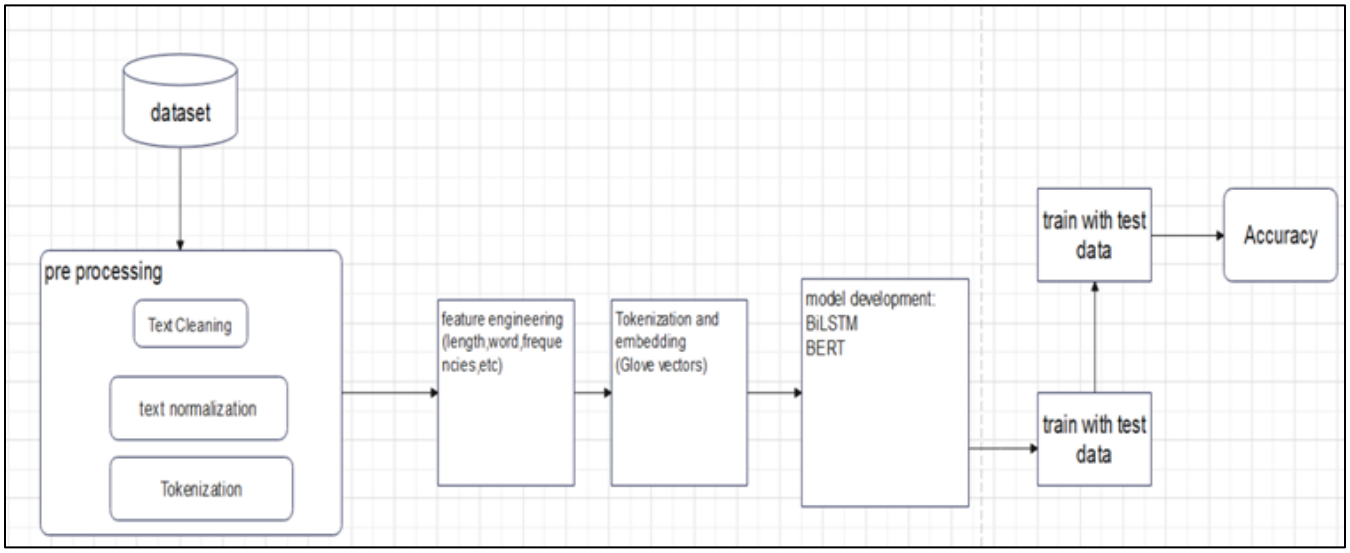

Fig. 2 - Block Diagram

IV. CONCLUSION

The project aimed to develop a robust sarcasm detection system leveraging advanced NLP techniques and machine learning models. Beginning with a comprehensive background study on sarcasm in textual data, the project's objective was to create a system capable of accurately identifying sarcastic statements within a given context. The methodology involved data preprocessing, feature extraction, model training using deep learning architectures such as LSTM and BERT, and evaluation using standard evaluation metrics. The results demonstrate the successful development of a sarcasm detection model with impressive accuracy and performance metrics. The model effectively differentiates between sarcastic and non-sarcastic text, providing valuable insights into the nuanced nature of sarcasm in natural language. The final concluding remarks highlight the significance of the developed system in various applications, including social media analysis, sentiment analysis, and conversational AI.

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