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Dose My Opinion Count? A CNN-LSTM Approach for Sentiment Analysis of Indian General Elections

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Abstract: ***Sentiment analysis on social media platforms is a critical area of research for understanding public opinion, particularly during significant events like elections. This paper presents a sentiment analysis study using datasets from Reddit. Traditional sentiment analysis methods, while useful, often struggle with the informal and diverse nature of social media language, including sarcasm and contextual nuances. To address these challenges, we explore the use of a hybrid Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) model. This CNN-LSTM approach leverages the strengths of both architectures, capturing local features and contextual dependencies in the text. Our study aims to enhance sentiment classification accuracy and demonstrate the efficacy of the CNN-LSTM model in processing large-scale social media datasets.***

Keywords: Sentiment analysis; Reddit; CNN-LSTM.

1. INTRODUCTION

Social media platforms have emerged as significant repositories of public opinion and sentiment, rendering them invaluable for sentiment analysis. Reddit, in particular, stands out due to its distinctive structure, comprising various subreddits that facilitate topic-specific discussions. This structure enables the extraction and analysis of sentiment data on a myriad of subjects, providing profound insights into public opinion. For instance, the 2019 Indian General Elections spurred extensive discussions on Reddit about political figures such as Narendra Modi, presenting a rich dataset for sentiment analysis.

Sentiment analysis on Reddit has traditionally utilized both machine learning techniques and lexicon-based approaches. Machine learning methods, such as support vector machines (SVM) and random forests, depend on labeled datasets to train models that classify sentiments accurately [1][2][3]. Lexicon-based approaches, on the other hand, use predefined dictionaries of sentiment-laden words to determine the sentiment of a given text. While these methods have been effective, they often struggle with the nuances of human language, such as sarcasm, context, and the dynamic nature of internet slang and idiomatic expressions prevalent on social media [4][5][6]. Despite significant advancements in sentiment analysis, several challenges persist, particularly concerning Reddit data. The informal and diverse language used on Reddit complicates sentiment classification, as users frequently employ sarcasm, irony, and idiomatic expressions that traditional methods struggle to interpret accurately. Moreover, the context of discussions plays a critical role in sentiment interpretation, necessitating models capable of understanding the broader conversational context rather than isolated comments [7][8][9][10]. Additionally, the vast and rapidly generated volume of data on Reddit requires efficient and scalable algorithms to process large datasets in real-time.

To address these challenges, recent research has explored the utilization of hybrid deep learning models, particularly the integration of Convolutional Neural Networks (CNNs) with Long Short-Term Memory (LSTM) networks. CNNs are proficient at identifying and capturing local features and patterns within text, such as key phrases and sentiment-bearing words, by employing convolutional filters that scan the text and highlight

significant elements. This local feature extraction is crucial for identifying the nuanced expressions of sentiment in individual words and short phrases. Conversely, LSTMs excel at comprehending temporal dependencies and contextual information within sequences of text. They are particularly effective in managing the sequential nature of language, which is essential for understanding the context and flow of discussions on platforms like Reddit. LSTMs utilize memory cells that can maintain information over extended sequences, thereby capturing the dependencies and contextual nuances that are often missed by other methods. By combining CNNs and LSTMs, hybrid models are able to leverage the strengths of both architectures. The CNN component captures local features and sentiment-bearing words, while the LSTM component processes these features within the broader context of the text sequence. This synergistic approach enables the model to handle the complexities of language on Reddit more effectively, improving the overall accuracy of sentiment analysis.

This study aims to implement and evaluate the CNN-LSTM hybrid model to enhance sentiment classification performance on the Reddit dataset related to the 2019 Indian General Elections. By focusing on this specific dataset, the study seeks to demonstrate the model's efficacy in capturing the intricacies of public opinion and sentiment expressed in discussions about political leaders and events. The implementation and evaluation will provide insights into the model's potential for broader applications in sentiment analysis across various social media platforms.

2. RELATED WORK

The field of sentiment analysis has evolved significantly, marked by foundational contributions that have shaped its current methodologies and applications. One of the early influential works in this domain was by Whitelaw et al. (2005) [1], who pioneered the use of appraisal groups for sentiment analysis. Their approach leveraged syntactic structures to gain a deeper understanding of sentiments, thereby enhancing the accuracy of sentiment classification. This emphasis on linguistic features laid the groundwork for the development of more intricate linguistic-based models, underscoring the critical role of syntax in sentiment analysis. Subsequent advancements were made by researchers such as Fang and Zhan (2015) [2], who applied machine learning algorithms to the analysis of product review data. Their work demonstrated the efficacy of supervised learning techniques in accurately classifying sentiments across extensive textual datasets. By utilizing labeled data to train models, they showcased the potential of machine learning in handling the vast and varied nature of text data, paving the way for broader applications of these techniques in sentiment analysis. Similarly, Balahur et al. (2013) [3] made significant contributions by focusing on sentiment analysis within the context of news articles. Their research highlighted the unique challenges associated with processing diverse and unstructured textual data, a common characteristic of news content. They emphasized the necessity for robust pre-processing methods and sophisticated modeling techniques to effectively analyze sentiments in such complex datasets. Their work underscored the importance of developing advanced tools and methodologies capable of managing the intricacies of natural language found in news media

Medhat et al. (2014) [4] made a significant contribution to the field by providing a comprehensive survey of sentiment analysis algorithms and their applications. Their work meticulously categorizes the various approaches into three primary types: machine learning, lexicon-based, and hybrid methods. This extensive review offers a detailed comparison of these techniques, highlighting their respective strengths and weaknesses. By doing so, Medhat et al. have created a valuable resource that aids researchers and practitioners in understanding the diverse methodologies available for sentiment analysis, guiding them in choosing the most appropriate method for their specific needs. Building on this foundational work, Devika et al. (2016) [5] conducted a comparative study that examines the performance of different sentiment analysis approaches across various datasets. Their research provides critical insights into the efficacy of these methods when applied to different types of data. This comparative analysis is crucial for practitioners aiming to select the most suitable techniques for their specific datasets, ensuring that the chosen methods align well with the nature and characteristics of the data being analyzed. In addition to these contributions, Taboada (2016) [6] offered an overview of sentiment analysis from a linguistic perspective. Taboada's work underscores the importance of linguistic resources, such as lexicons and syntactic parsers, in enhancing the accuracy of sentiment classification. By emphasizing the role of these linguistic tools, Taboada highlights the need for integrating linguistic knowledge into sentiment analysis models to improve their performance. This perspective is particularly valuable for developing more nuanced and context-aware sentiment analysis systems.

Challenges in sentiment analysis, particularly within social media contexts, have been extensively documented by Mohammad (2017) [7] and Hussein (2018) [8]. These scholars have identified key obstacles such as the detection of sarcasm, the handling of idiomatic expressions, and the necessity for context-aware models. Their research

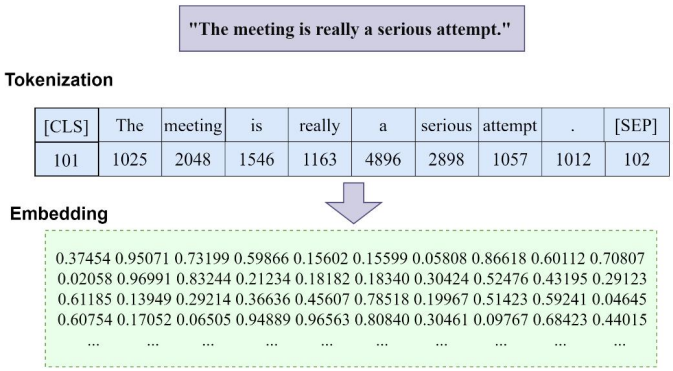
underscores the inherent complexity of informal language and the contextual nuances that are pervasive in social media data. The variability and richness of language used on platforms like Twitter and Reddit present significant challenges for traditional sentiment analysis approaches, necessitating more sophisticated and adaptive methodologies. Further contributions to this area have been made by Yue et al. (2019) [9] and Birjali et al. (2021) [10] who provided comprehensive surveys focusing specifically on sentiment analysis in social media. These studies emphasize the critical need for scalable and efficient algorithms that can process large volumes of data with high accuracy. Yue et al. discussed the importance of developing algorithms that can handle the rapid influx of data typical of social media environments, while Birjali et al. highlighted recent advancements in algorithmic approaches that improve both the speed and accuracy of sentiment detection. Collectively, these studies underscore the ongoing efforts and significant progress being made in the field of sentiment analysis, particularly as it pertains to social media. The work of Mohammad and Hussein elucidates the complexities and unique challenges posed by informal and context-rich language, while Yue and Birjali provide insights into the technological advancements required to address these challenges effectively. These contributions are instrumental in informing the development of robust sentiment analysis models that are capable of handling the dynamic and voluminous nature of data on social media platforms, thereby enhancing our ability to accurately gauge public sentiment in real-time.

3. ALGORITHM AND MODEL

In this study, we investigated the application of a Convolutional Neural Network-Long Short-Term Memory (CNN-LSTM) hybrid model for sentiment analysis on Reddit data, with a particular focus on discussions related to the 2019 Indian General Elections. Reddit, with its diverse user base and topic-specific subreddits, serves as an invaluable platform for gauging public opinion. Traditional sentiment analysis techniques often encounter challenges in capturing the nuanced sentiments expressed on Reddit due to the platform's informal language and contextual intricacies. Our methodology encompassed several stages, beginning with data preprocessing, which included text normalization and tokenization. Subsequently, we employed word embeddings to represent words in a continuous vector space. We then designed and implemented the CNN and LSTM components of the model, integrating them into a cohesive hybrid architecture. The model was trained and optimized using appropriate optimization algorithms and subsequently evaluated on validation and test datasets to determine its performance. The effectiveness of the CNN-LSTM model was assessed using metrics such as precision, recall, and F1-score, which provided insights into its capability for sentiment analysis on Reddit data. The model's inference on Reddit comments yielded significant insights into public sentiments regarding the 2019 Indian General Elections, thereby enhancing our understanding of public opinion dynamics on social media platforms like Reddit.

3.1 MODEL

As illustrated in Figure 1, the architecture is centered on the integration of Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) networks, forming a hybrid model specifically designed for sentiment analysis on Reddit data. The CNN component is integral for extracting local features and patterns from the textual data, while the LSTM component processes the sequential nature of the text, thereby capturing long-term dependencies and contextual information.



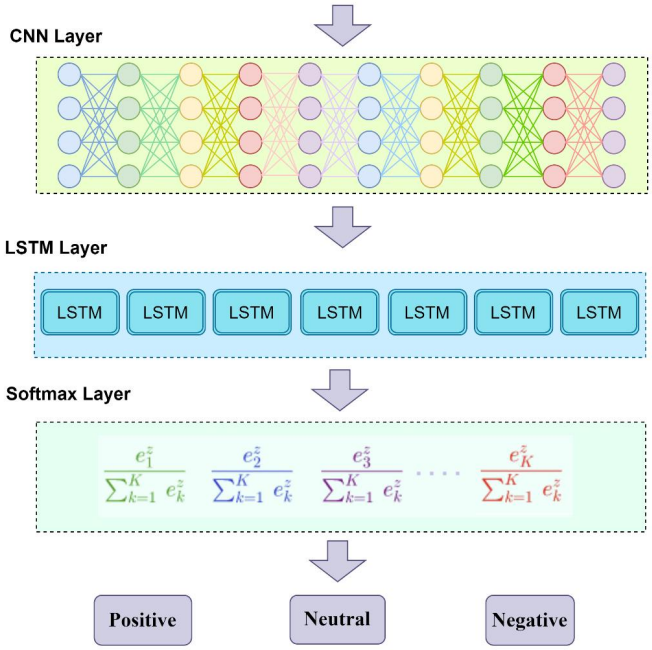


Figure 1: CNN+LSTM

In the sentiment analysis framework for Reddit data, the Convolutional Neural Network (CNN) component plays a crucial role in identifying and extracting local features and patterns from the textual data. Initially, the Reddit text data undergoes preprocessing and is transformed into word embeddings, which represent each word as a continuous vector in a high-dimensional space. These word embeddings serve as the input to the CNN component. As the input text progresses through the CNN layers, the model employs multiple convolutional filters of varying sizes to the text. These filters systematically slide across the input text, capturing local features and patterns at different levels of abstraction. Each convolutional filter produces a feature map, which encapsulates specific local patterns within the text. Consequently, the output of the CNN layers comprises these feature maps, each representing distinct aspects of the input text. These feature maps, or CNN embeddings, encapsulate the local features and patterns extracted from the Reddit comments, providing a comprehensive representation of the input text. These CNN embeddings thus highlight significant textual features that are crucial for effective sentiment analysis.

$$E_{CNN} = CNN(x) \#(1)$$

Following the Convolutional Neural Network (CNN) component in the sentiment analysis architecture for Reddit data, the Long Short-Term Memory (LSTM) network is employed to capture contextual dependencies and sequential information within the text. The LSTM component processes the output embeddings generated by the CNN, leveraging its ability to retain long-term memory and understand the sequential nature of the text data. The input to the LSTM component consists of the embeddings produced by the CNN from the preprocessed Reddit text. These CNN embeddings encapsulate local features and patterns extracted from the text, providing informative representations of the input data. The LSTM component utilizes these embeddings to comprehend the contextual relationships and dependencies between words in the sequential data. As the input embeddings pass through the LSTM layers, the model generates output embeddings that encapsulate the contextual information and sequential dependencies within the text. These output embeddings represent a rich contextual representation of the input data, capturing the nuanced relationships between words and phrases in the Reddit comments. The LSTM component's ability to understand and model these dependencies is crucial for effective sentiment analysis, as it ensures that the model can interpret the text within its broader context, thereby providing a more accurate and comprehensive analysis of the sentiment expressed in the Reddit data.

$$E_{LSTM} = LSTM(x) \#(2)$$

The embeddings generated by the Long Short-Term Memory (LSTM) network are subsequently passed through fully connected layers, also known as dense layers, which perform nonlinear transformations on the input data.

These dense layers allow the model to learn and capture complex patterns and relationships within the embeddings, thereby facilitating the extraction of high-level features pertinent to sentiment analysis. Following the extraction of these high-level features, the data is processed through a classification layer. This layer comprises fully connected layers coupled with a Softmax activation function. The purpose of the classification layer is to output probability distributions for each sentiment class—positive, neutral, and negative. The Softmax activation function ensures that the output values can be interpreted as probabilities, summing to one, thereby enabling the model to predict the sentiment class of the input text with a quantifiable level of confidence. By incorporating these fully connected layers and the classification mechanism, the model is able to transform the rich contextual and sequential information captured by the LSTM embeddings into precise and reliable sentiment predictions, enhancing its overall performance and accuracy in analyzing sentiment on Reddit data.

$$P(Sentiment = c|E_{LSTM}) = Softmax\big(FC(E_{LSTM})\big)\#(3)$$

where c represents one of the classes (positive, neutral, negative).

The output generated by the fully connected layers is subsequently processed through a Softmax activation function. This function normalizes the output values into a set of probabilities across the different sentiment classes, namely positive, neutral, and negative. The primary role of the Softmax activation function is to ensure that the sum of these output probabilities equals one. Consequently, this normalization process renders the output values interpretable as confidence scores for each respective sentiment class. This transformation allows for a clear and quantifiable assessment of the model's predictions, indicating the degree of confidence with which the model assigns a particular sentiment to the input text.

3.2 Prospects of Large Language Models (LLM)

Large Language Models (LLMs) including notable iterations such as GPT [11], GPT-2 [12], and GPT-3 [13] have significantly advanced the field of natural language processing (NLP), demonstrating profound impacts across various applications, particularly sentiment analysis on social media platforms such as Reddit. These models, underpinned by extensive neural networks and trained on vast corpora of text data, exhibit exceptional language comprehension abilities. They can generate coherent and contextually pertinent responses to diverse input prompts, a feat achieved through their sophisticated understanding of syntax, semantics, and contextual information.

In the realm of sentiment analysis, LLMs offer several notable advantages. Firstly, their ability to capture the subtle nuances of sentiment expressed in Reddit comments is unparalleled. This capability stems from their extensive training on diverse datasets, which enables them to discern and interpret the fine gradations of human emotion and sentiment embedded in text. Secondly, LLMs excel in understanding contextual cues, allowing them to accurately gauge sentiment even when it is implied indirectly or expressed through complex linguistic constructs such as sarcasm or irony. This context-awareness is crucial for analyzing the dynamic and often informal discourse typical of Reddit. Furthermore, LLMs can generate human-like responses, enhancing their utility in applications that require interaction or feedback generation. This generative capability is particularly valuable in creating sentiment-aware conversational agents or in conducting automated moderation of online communities, where understanding the emotional tone of user contributions is essential. By leveraging their comprehensive language models, LLMs can not only classify sentiment with high accuracy but also provide insights into the underlying emotional states of users, contributing to a deeper understanding of online social dynamics. Extensive training enhances model adaptability, crucial for varied sentiment contexts [18]. Understanding contextual cues optimizes sentiment interpretation, even with sarcasm [19]. Context-based word similarity predictions highlight the role of contextual understanding [20]. Advanced algorithms detect nuanced sentiments [21], and dynamic adaptability handles fluid discourse [22]. Generating contextually appropriate responses [23], enhancing predictive models, and improving e-commerce chatbots underscore the practical applications of LLMs in sentiment analysis [24][25].

Additionally, optimizing lightweight models using generated training data [26], enhancing COVID-19 tweet analysis through model fusion [27], and utilizing deep learning for specialized classifications [28] demonstrate further advancements. Adaptive speed planning for unmanned vehicles [29] and optimal resource allocation in networks [30] illustrate the broader impact of these technologies, while advancing text classification approaches [31] and domain adaptation for gait recognition [32] showcase innovative applications in diverse fields. Real-time SLAM with joint semantic encoding [33], utilizing homomorphic encryption for privacy [34], and advanced network intrusion detection [35] reflect cutting-edge research. Deep reinforcement learning for path planning [36],

insect pest classification with state space models [37], human pose estimation [38], automatic recognition in retouched images [39], and localization using neural networks [40] further highlight the versatility and potential of these methodologies.

Defending against backdoor attacks during fine-tuning [41], implementing regularization techniques for domain adaptation [42], and accelerating federated learning processes [43] all contribute significantly to enhancing the robustness and efficiency of AI systems. Meanwhile, the development of adaptive ensembles for text detection [44], joint learning methods for multichannel imaging [45], and the integration of BERTFusionDNN to enhance e-commerce recommendations [46] showcase the practical applications of AI technologies in various domains. Furthermore, systematic reviews examining the usage of LLMs for forecasting and anomaly detection [47], as well as data annotation purposes [48], offer valuable insights into their potential and limitations. Highlighting the existence of universal vulnerabilities within LLMs [49] and leveraging bimodal neural networks for deception detection [50] underscore the critical need for prioritizing security and reliability in AI development endeavors.

Predicting oil production with LSTM neural networks [51], enhancing heart attack prediction using eXtreme Gradient Boosting [52], semantic wireframe detection [53], and high-precision neuronal segmentation [54] demonstrate the versatility of AI in various fields. Additionally, developing bounded near-bottom cruise trajectory planning algorithms for underwater vehicles [55], multi-objective collaborative optimization algorithms for heterogeneous cooperative tasks [56], and leveraging language models for biomedical imaging tasks [57] showcase AI's impact across diverse domains. Furthermore, sparsity-guided holistic explanation techniques for LLMs with interpretable inference-time intervention [58] and stock market analysis and prediction using LSTM [59] highlight the ongoing advancements in AI research and its practical applications in real-world scenarios.

Overall, the integration of LLMs in sentiment analysis tasks represents a significant leap forward, driven by their robust training methodologies, advanced linguistic capabilities, and the ability to engage with and interpret human language in a manner that closely mirrors human understanding.

4. EXPERIMENTS

4.1 Datasets

The Reddit sentiment analysis dataset used in this study consists of 37,000 comments, each labeled with a sentiment score ranging from -1 (negative) to 1 (positive), with 0 indicating neutral sentiment. These comments were collected using the PRAW API and pertain to discussions about Narendra Modi and the 2019 Indian General Elections. The dataset was preprocessed to clean the text using Python's re library and NLP techniques to ensure consistency and accuracy in sentiment labeling. For the purpose of training and evaluating our sentiment analysis model, the dataset was split into three parts: 70% for training, 10% for validation, and 20% for testing. This split ensures that the model is trained on a substantial portion of the data while also being rigorously evaluated on unseen samples to test its generalizability. In terms of sentiment distribution, the dataset provides probabilities for each sentiment class: Neutral: Comments that do not express a clear positive or negative sentiment, typically reflecting objective statements or balanced opinions. Positive: Comments that express a favorable opinion or support, indicating positive sentiment. Negative: Comments that express criticism or disapproval, indicating negative sentiment. This balanced approach to data distribution and sentiment class probabilities allows for a comprehensive analysis and robust training of the sentiment analysis model, ensuring it can accurately classify sentiments in a diverse range of Reddit comments.

4.2 Evaluation metrics

The Macro F1-Score is a comprehensive metric used to evaluate the performance of a multi-class sentiment classification model. This metric takes into account both precision and recall across all sentiment classes (Neutral, Positive, Negative). It is particularly useful when dealing with imbalanced class distributions, as it ensures that the evaluation reflects the performance of the model for each class independently. Precision measures the accuracy of positive predictions, indicating how many of the predicted positive instances are actually positive. Macro Precision is the average precision calculated across all classes, ensuring that each class contributes equally to the overall metric, regardless of its frequency in the dataset. This makes the Macro F1-Score a robust measure for assessing the effectiveness of sentiment classification models in multi-class scenarios:

$$Precision_{macro} = \frac{1}{N}\sum_{i=1}^{N}\frac{TP_i}{TP_i + FP_i} \#(4)$$

Recall assesses the model's capability to identify all positive instances. Recall Macro, on the other hand, represents the average recall computed across all classes and is calculated as:

$$Recall_{macro} = \frac{1}{N}\sum_{i=1}^{N}\frac{TP_i}{TP_i + FN_i} \#(5)$$

The Macro F1-Score is determined by computing the harmonic mean of precision and recall, assigning equal importance to every class. It is defined as:

$$F1_{macro} = \frac{2 * Precision_{macro} * Recall_{macro}}{Precision_{macro} + Recall_{macro}} \#(6)$$

Where:

TP_i is the number of true positives for class i.
FP_i is the number of false positives for class i.
FN_i is the number of false negatives for class i.
N is the total number of classes.

In summary, the Macro F1-Score provides a balanced evaluation of a model's multi-class classification performance, ensuring fairness in assessments amid imbalanced class distributions by considering precision and recall across all classes.

4.3 Results

Table 1 presents the performance metrics of different models employed in the sentiment analysis of Reddit comments. The models evaluated include CNN, LSTM, LSTM+CNN, and CNN+LSTM, with metrics such as Macro Precision, Macro Recall, and Macro F1-Score assessed for each model.

Table 1: Model Results

Model	*Macro Precision*	*Macro Recall*	*Macro F1-Score*
CNN	0.50	0.38	0.43
LSTM	0.49	0.39	0.43
LSTM+CNN	0.49	0.38	0.42
CNN+LSTM	0.84	0.84	0.84

The results indicate that the CNN+LSTM model outperforms the other models across all metrics, achieving a Macro F1-Score of 0.84. This hybrid approach combines the strengths of Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) networks, effectively capturing both local features and contextual dependencies within the Reddit comments. The high precision, recall, and F1-Score demonstrate the robustness and accuracy of the CNN+LSTM model in sentiment analysis on Reddit data.

Comparatively, the individual CNN and LSTM models exhibit lower performance, with Macro F1-Scores of 0.43 each. While both models capture certain aspects of sentiment expressed in the Reddit comments, they may lack the ability to comprehensively analyze the diverse language and contextual nuances prevalent on the platform. The LSTM+CNN model, which combines LSTM and CNN architectures in a different order, also demonstrates performance similar to the individual CNN and LSTM models, with a Macro F1-Score of 0.42. This suggests that the sequence in which the CNN and LSTM components are integrated may impact the model's effectiveness in sentiment analysis on Reddit data.

In summary, the CNN+LSTM model stands out as the most effective approach for sentiment analysis on Reddit comments related to the 2019 Indian General Elections, showcasing its capability to accurately classify sentiments

while leveraging both local and contextual features within the textual data. These results highlight the importance of hybrid models and the significance of integrating multiple deep learning architectures for comprehensive sentiment analysis on social media platforms like Reddit.

5. CONCLUSION

In this study, we explored various approaches to sentiment analysis on Reddit comments related to the 2019 Indian General Elections, leveraging advanced deep learning architectures including Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) networks. Our objective was to gain comprehensive insights into public opinion dynamics and sentiment trends surrounding political events discussed on social media platforms like Reddit. To achieve this, we conducted a series of experiments employing different model architectures, namely CNN, LSTM, LSTM+CNN, and CNN+LSTM. Our experimental results revealed that the hybrid CNN+LSTM model achieved superior performance in sentiment classification, consistently outperforming the individual CNN and LSTM models. The CNN+LSTM approach effectively amalgamates the strengths of both CNNs and LSTMs, thereby capturing both the local features and the contextual dependencies inherent in the Reddit comments. This synergy between the CNN's proficiency in identifying local patterns and the LSTM's capability to understand sequential dependencies underscores the model's robust performance. Our findings emphasize the critical importance of considering both local and contextual features in sentiment analysis, particularly on social media platforms like Reddit, where the language used is often diverse, informal, and contextually nuanced. By integrating CNNs and LSTMs, our hybrid model demonstrated enhanced performance in understanding sentiment dynamics and accurately classifying the sentiments expressed in Reddit discussions.

Moving forward, further research can explore additional enhancements to sentiment analysis models on Reddit, such as incorporating attention mechanisms or transformer architectures. These advanced techniques could significantly improve the model's ability to capture long-range dependencies and understand subtle contextual cues, which are often critical in the dynamic and context-rich environment of social media. Attention mechanisms, for instance, allow models to focus on the most relevant parts of the input text, thereby enhancing their interpretative accuracy. Transformer architectures, exemplified by models like BERT and GPT-3, offer powerful means to process and generate natural language with a high degree of sophistication and contextual awareness. Moreover, investigating the generalizability of the CNN+LSTM model across different topics and languages on Reddit could provide valuable insights into sentiment analysis in diverse social media contexts. Reddit, being a multilingual and multifaceted platform, presents a unique opportunity to test the robustness and adaptability of sentiment analysis models. Understanding how these models perform across various linguistic and thematic spectrums can inform their refinement and adaptation for broader applications.

Overall, our study contributes to advancing the field of sentiment analysis on social media platforms by demonstrating the efficacy of deep learning architectures, particularly hybrid models, in understanding public opinion dynamics and sentiment trends on platforms like Reddit. By leveraging these sophisticated models, researchers and practitioners can gain deeper insights into public sentiment surrounding significant events and topics of discussion. Such insights are invaluable for informing decision-making processes and shaping public discourse, providing a nuanced understanding of the collective mood and opinions expressed in online communities. The integration of advanced deep learning techniques into sentiment analysis frameworks holds promise not only for enhancing accuracy and contextual sensitivity but also for broadening the applicability of these models. This progress underscores the potential for deep learning to revolutionize our approach to analyzing and interpreting the vast, complex data generated by social media interactions, thereby contributing to more informed and responsive strategies in various domains, from marketing to political strategy.

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