

AI-Based Sarcasm Detection Using LSTM Networks

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Abstract - Sarcasm detection is a significant task of natural language processing since sarcastic utterances say something completely contrary to what they actually mean and machines fail to understand this contradiction. The system we propose is based on an Artificial Intelligence based sarcasm detection approach which uses Long Short-Term Memory Network, an efficient deep learning model which can learn the features and context in the word sequences to determine if the utterance is sarcastic or not. Text data is extracted from web sources like comments or social media data. Data is preprocessed by removing noises from text, tokenizing it, and then converting words into vector form. An LSTM is trained to determine whether the utterance is sarcastic on basis of word sequence analysis and their contextual features. Precision, recall and F1-score are the metrics used to evaluate the efficiency of our model. The primary application of this project would be to enhance sentiment analysis. Other applications would be to detect sarcasms in web discussions and help with other systems such as detecting cyberbullying, monitoring social media and opinion detection. In the future the model could be improved using more data to train, combine with complex architectures like transformer neural networks and incorporating features like emoticons or deeper contextual analysis.

I. INTRODUCTION

In the current digital age, human interaction has greatly shifted to online environments like social networks, instant messaging, blogs and forums. Humans communicate emotions, opinions and ideas using written texts, and computers need to accurately understand human language. This necessity to led the development of AI and NLP.

The common challenges that are faced by NLP is the identification of sarcasm. Sarcasm is a stylistic device wherein the statement made is contrary to the intended meaning, such as saying "Great job!" in an ironic manner after a certain failure has occurred. This often challenges for machines because it highly depends on the context, tone of users and even outside knowledge which are typically absent in the texts being analyzed.

Traditional machine learning techniques often fail to effectively detect sarcasm since they utilize simpler features like keyword analysis or word frequency, and are incapable of recognizing deep context and sequential word relations. Therefore, deep learning models like Recurrent Neural Networks (RNNs) are applied.

Among all types of RNNs, LSTMs (Long Short-Term Memory networks) are powerful models that are suitable for text modeling. LSTMs are capable of retaining long-term dependencies of sequential data, therefore they are suitable for sarcasm detection since the context is crucial to identify the real intended meaning. LSTM's use a combination of memory cells and gating mechanisms in order to store and manipulate information throughout time, allowing it to comprehend complex language structures.

To perform this project on sarcasm detection using AI, textual data is collected from sources like social media (tweets, comments or reviews) and it is pre processed (noise reduction, tokenization, conversion to numerical features). The LSTM model is then trained on this data and is capable of classifying whether or not the sentence is sarcastic.

The objective of this project is to build an efficient sarcasm detection system that leverages LSTMs for more accurate sentiment analysis. Identifying sarcasm can be useful for social media monitoring, customer review analysis, chatbot design and for the detection of cyberbullying. Identifying true intentions of user inputs allow organization to make better decision and provide better services.

Future enhancements may include the addition of other models like attention mechanism, transformer models, contextual embedding to enhance the system's performance for identifying complex emotions and subtle language. social media monitoring, customer review analysis, chatbot design and for the detection of cyberbullying. Identifying true intentions of user inputs allow organization to make better decision and provide better services.

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Workflow of sarcasm detection by LSTM technique:

A. Classification:

The classification is the process in AI-based sarcasm detection using LSTM networks which involves identifying whether the given text is sarcastic or non-sarcastic based on the learning patterns.

Initially, the input text is pre processed by using the techniques like cleaning, tokenizing, and converting it into numerical form by methods like word embeddings and padding. The data is then passed into the LSTM model, which analyzes the sequence of words and captures contextual relationships within the sentence. The LSTM network uses its memory cells and gating mechanisms to preserve important information and discard unwanted details, allowing it to understand the variations and hidden meanings often present in sarcastic expressions. After processing the input, and output from the LSTM layer, it is then passed to a dense (fully connected) layer with an activation function such as curved, which produces a probability score. Based on this probability score, the system is classified into two categories: sarcastic or non-sarcastic. This classification process enables the model to make accurate predictions by considering both the structure and context of the sentence, making it more effective than traditional methods.

B. Data pre-processing:

In first phase of AINLP-ALBTCN the is data pre-processing. A text should be pre-processed such that they are suitable to be used for learning and representation purpose. A pre-processing is a technique of changing the data to meaningful input data that useful for the DL and ML tasks. Main purposes of pre-processing are removing stop words, slangs, punctuations and others unusable text in text data. It should be noted that, an unfriendly words in the language of Arabic is potentially harm the detection performance on the Arabic sarcasm recognition task. A non- Arabic words, punctuations, and stop words should be dropped during pre-processing. Different groups or collections of function executed on top of stemming and tokenization have primarily necessitated in practice. A refined text presentation has been derived with various up-to-date and old pre-processing techniques. Tokenization is the process by which text is divided into words, characters or phrases (words are termed as tokens). This approach changes text/sentence to words. In the following steps, the above words will be presented by their weight/embedding vectors depending on the used model. ML would then drop off stop words.

II. BASICS OF SARCASM DETECTION

Sarcasm detection is the task in natural language processing that is specially designed to identifying instances of statements where the actual meaning of the words use to differ from the speaker's intended meaning.

Sarcasm is often used for purposes such as criticism, or humor, making it challenging for machine to understand, especially in text formats, due to the absence of modulation, body language, or facial expressions. For event, "That was just perfect!" might express frustration depending on the context. The Accurate sarcasm detection is difficult for improving sentiment analysis accuracy, as misleading sarcastic statements may cause negative sentiment to be wrongly classified as positive. Sarcasm can be manifested in several ways such as including verbal, situational, and Sarcastic styles and often involves contrast, exaggeration, and a dependence on context. It is, however, hindered by ambiguity, lack of context and variations in cultural expression. Conventional techniques employing keywords and rules are generally insufficient to capture the complexity of sarcasm, while advanced AI-based techniques such as LSTMs prove to be efficient as they can process sequential patterns and contextual relationships within text data. Thus, sarcasm detection has a significant role in various applications such as social media analysis, chatbots, customer service systems and cyberbullying detection for comprehending the real intentions behind user-generated content.

III. FEATURES

- i. Contextual understanding: It is the ability of LSTM to capture the sequence and relationships between words to identify the true (often opposite) meaning in sarcastic sentences.
- ii. LSTMs are able to interpret a sentence's context rather than only individual words. Context plays a crucial role in understanding whether or not a sentence is being said sarcastically.
- iii. Sequential data: LSTM works as a sequence of words, preserving the order of the words so it's important to analyze early word context and late word context.
- iv. Long-term dependency: The main benefit that LSTM provides over traditional models is that it's able to remember the context of lengthy sequences. Sarcastic content often has dependencies that occur much earlier in a text.
- v. Memory structure: Each LSTM unit has memory cells, gates(input, output, and forget), that regulate what to remember and what to forget enabling it to understand language more effectively.

- vi. Better sentiment analysis: It helps improve sentiment analysis when statements have been expressed sarcastically, because, without this model, it would be classified as positive or negative.
- vii. Automated feature selection: Instead of using manually programmed features as input, LSTMs automatically learn the necessary features.
- viii. Linguistic ambiguity handling: The ability to process context makes it more possible to capture an understanding of an indirectly phrased statement.
- ix. Scalability: The model is scalable to huge text datasets, like that of social media posts, thus being readily adaptable to real-world applications.
- x. Compatibility with NLP methods: The system can be easily combined with various Natural Language Processing techniques like tokenization, word embeddings (Word2Vec and GloVe), and preprocessing methods.
- xi. High accuracy compared to conventional methods: LSTMs provide an accurate model that outperform models based on conventional methods such as Naive Bayes, and Support Vector Machines for sarcasm detection tasks.
- xii. Real-time processing capability: The system can process language in real-time for use in chatbots, virtual assistants, social media monitoring tools etc.
- xiii. Enhancement adaptability: With the help of additional modules, such as the attention mechanism and deep learning architectures, this model can be improved even further.

IV. CHALLENGES IN SARCASM DETECTION

One of the many reasons it is difficult to detect sarcasm is that detection doesn't only rely on the explicit wording of a message, but also requires implicit and contextual interpretations. Perhaps the most considerable challenge is that sarcasm relies heavily on context. A sentence that seems positive to someone, in itself may have an opposite sentiment when placed within a context or discourse. A further challenge is the lack of tone, facial expression and vocalisations. Whereas people use their vocal intonations and expressions to identify sarcastic utterances, in written text, no such features are available which make it difficult for machines to detect sarcasm effectively. This challenge also occurs when positive vocabulary is used to express negative emotion (contradiction between word and sentiment) which complicates traditional sentiment analysis methods.

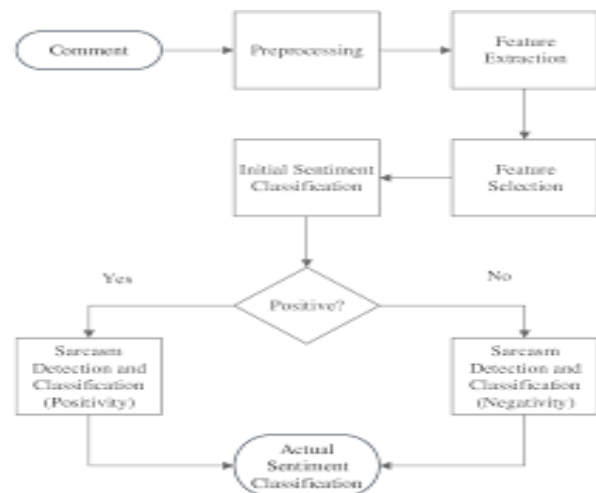
The use of sarcasm also varies from different culture, cultures may have differences in expressing it, and from person to person in how it is expressed, making it extremely difficult to build a context-independent detector.

Additionally, because much of the sarcasm is displayed within a very short and limited context, for instance a social media post, a challenge to this detection task is established. The fact that people don't always agree even when asked to label a sarcastic utterance implies a training data issue. All in all, sarcasm detection is an intrinsically difficult task.

How Does LSTM Works:

In this paper Long Short-Term Memory (LSTM) networks are fundamental in achieving precise Sarcasm Detection in text data. Sarcasm is indeed an interesting phenomenon and is complicated to detect since the exact meaning of a sentence is generally based on its context. However LSTM networks manage to perform better by processing the order and relationship of the words in a given sentence.

LSTM networks manage to memorize significant information in previous parts of a sentence and link them with other parts that are coming in the subsequent parts of the sentence. For instance, a sentence that sounds pleasant in the beginning may carry negative sentiment as and when we reach its end, and the Long Short-Term Memory (LSTM) network successfully manages to recognize such difference and thereby detecting the implicit sentiment by storing contextual information in its memory cells.



Another aspect that the LSTM networks assist us in this work is by having the ability to handle long-term dependencies.

When it comes to sarcasm, the tone and the contextual relationship may carry out over numerous words, therefore it is important to keep track of previous context and LSTM does so by utilizing the input, output and forget gates.

The Long Short-Term Memory (LSTM) network is utilized in this paper to train a model with labelled text data consisting of both sarcastic and non-sarcastic sentences. Through this training, the model learns the necessary patterns, tone, contextual cues related to sarcasm and thus it can predict if a new text contains sarcasm with an adequate level of accuracy.

In summary, the Long Short-Term Memory (LSTM) network assist in detecting sarcasm by recognizing contextual data, analyzing sequence of words, eliminating classification errors in sentiment analysis and improving performance compared to traditional machine learning algorithms.

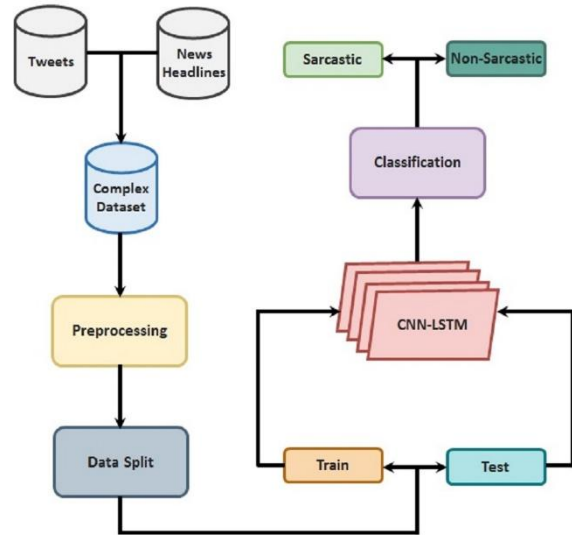
V. IMPLEMENTATION

Building the AI-based sarcasm detection system using LSTMs: After creating suitable datasets (sarcastic and non-sarcastic sentences from sources such as social media posts, reviews, and blogs), data preprocessing involves removing noise such as special characters, URLs, and noise words. The text then needs to be tokenized and normalized into machine-readable form. Following this, it's converted into a vector form by means of tokenization, word embeddings and then padding. Then, it is split into testing set and training set to check the performance. An LSTM-based deep learning model can then be built with the required layers such as embedding, LSTM, and a dense output layer and is then trained with proper loss function and optimizer to identify sarcasm in sentences. It can then be tested to check its accuracy, precision, recall and F1 score and the model is then ready to predict and also used in many applications such as in the chatbot, social media monitoring systems, etc.

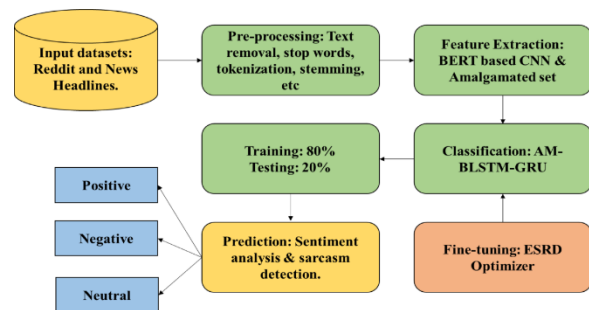
Area of Application of AI-Based Sarcasm Detection Systems:

The area of application of AI-based sarcasm detection systems is widespread and growing due to the increased prevalence of digital communication. It is predominantly applied in a bid to make machine understanding of human language more advanced, through detection of true meaning behind sarcastic statements.

One of the prime areas of application is sentiment analysis, wherein the detection of sarcasm lends itself to a more accurate result as misinterpretation is avoided.



It is important in social media analysis where user generated text, which includes comments, tweets, posts and reviews can be studied and better understanding and opinion of the public can be attained for businesses and other entities. It can be of use in the field of customer feedback analysis. The system can offer more comprehensive understanding of customer perception of product and services and ways to better it.

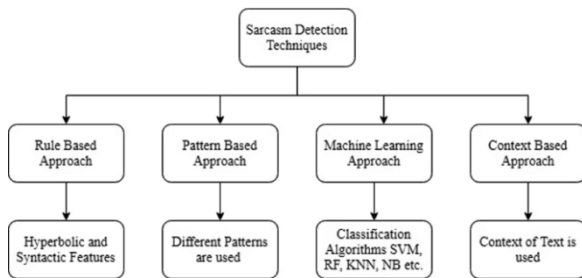


Another important aspect is the role it plays in chatbot and virtual assistants wherein sarcasm detection can add to a more conversational approach between humans and machines as it can provide the system with a deeper understanding of the user and respond more intuitively and appropriately. Cyberbullying detection and content moderation also utilize this system for similar reasons; sarcasm is often used to imply negative sentiment and malicious content in a covert way.

It also helps in analyzing public opinion and recommendations from people about services or products as the ability to recognize sarcasm indicates a more comprehensive understanding of the user's sentiment. It can also be useful in opinion mining. Recommendations and market research rely on detailed and proper analysis of customer needs.

With advancements in AI, the scope is expanding towards multilingual sarcasm detection, real-time processing, and multimodal analysis (combining text, images, and voice).

Overall, AI-based sarcasm detection systems have a broad scope in improving human-computer interaction and enabling machines to understand complex human emotions and language more effectively.



VI. CONCLUSION

In essence, the AI based sarcasm detection on LSTM can contribute in understanding human language better and accurately identify the implicit intent behind sarcasm. Sarcasm inherently conveys meanings that contradict the literal meaning of the text; thus the conventional methods are not able to interpret sarcasm correctly. LSTM on the other hand, is an effective model to handle this due to its nature of remembering contexts and the sequential relations in the input text. This project has proved the use of deep learning approach for enhancing sentiment analysis by lowering the misclassification rate and helping in applications like social media monitoring, chatbots and analysis of customer feedback. The memory and learning characteristics of the LSTM approach will make the system much efficient for handling complex language patterns. The performance can be further improved in the future with the use of advanced methods such as attention mechanisms, transformer models and multi-modal analysis. With these improvements, the system can serve as a more intelligent system in understanding human language and thus leading to more efficient human-computer interactions.

With increasing advancements of AI, it can also be expanded to various domains like multilingual sarcasm detection, real-time processing, multimodal detection etc. In short, the area of application for AI-based sarcasm detection systems is vast and has a direct bearing in making human-computer interactions more intuitive and advanced.

VII. FUTURE ENHANCEMENT

Scope of AI-Based Sarcasm Detection Systems:

The scope of AI-based sarcasm detection systems is wide and continuously expanding due to the growing use of digital communication. These systems are mainly used to improve the understanding of human language by identifying the true intent behind sarcastic statements. One of the major areas of scope is sentiment analysis, where detecting sarcasm helps in providing more accurate results by avoiding misinterpretation of opinions.

Some of the future enhancement directions that could be adopted to further build upon this project would be: to incorporate sophisticated techniques such as attention mechanisms that can help the model learn to pay more attention to the essential words within the given text sentence and to utilize sophisticated transformer-based models such as BERT for better context understanding. Additionally, the model could be enhanced by applying multi-modal sarcasm detection, where one analyzes images, emotions and voice-tone alongside the text for even greater accuracy. Real-time processing could also be implemented, enabling the system to be more helpful in live chats and data streams and thus make it efficient and user-friendly. Finally, use of larger and more diverse data-sets could improve performance of the model on different languages and culture

In the field of social media analysis, sarcasm detection plays a crucial role in analyzing user-generated content such as comments, tweets, and reviews. It helps organizations, businesses, and researchers understand public opinion more effectively. The system is also highly useful in customer feedback analysis, where companies satisfaction and improve their products and services.

Another important scope is in chatbots and virtual assistants, where sarcasm detection enhances communication by enabling systems to respond more naturally and intelligently. It is also significant in cyberbullying detection and content moderation, as sarcasm is often used to indirectly express harmful or offensive messages.

Furthermore, these systems can be applied in opinion mining, recommendation systems, and market research to better understand user preferences and trends.



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