Recommendation Using Deep Sentiment Analysis

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Abstract: In the rapidly evolving landscape of E-Commerce, the effectiveness of recommendation systems plays a pivotal role in enhancing user experience and engagement. This paper presents a novel recommendation system that leverages deep sentiment analysis of user reviews, combining Long Short-Term Memory Collaborative Filtering (LSTM-CF), Bidirectional Encoder Representations from Transformers (BERT), and hybrid deep learning algorithms to provide accurate and context-aware product recommendations. The proposed recommendation system is evaluated on a real-world E-Commerce dataset, demonstrating superior performance compared to traditional recommendation systems and standalone deep learning models. The integration of sentiment analysis enhances the system's ability to consider user emotions and opinions, resulting in more personalized and accurate product recommendations. The hybrid recommendation system presented, showcases the potential of combining LSTM-CF and BERT with sentiment analysis to improve the accuracy and personalization of E-Commerce recommendations.
Keywords: sentiment analysis; reviews; classification; recommendation system

1. Introduction

In the era of digital commerce, the exponential growth of online platforms has led to an overwhelming abundance of products and services. With this abundance, users face the challenge of sifting through a vast array of options to find products that align with their preferences and needs. In response to this challenge, recommendation systems have emerged as essential tools for enhancing user experience, engagement, and satisfaction in E-Commerce. Traditional recommendation systems often rely on collaborative filtering or content-based approaches to suggest products to users. However, these methods have limitations in capturing the intricate nuances of user preferences, especially when dealing with unstructured data such as user reviews. System leverages the power of Bidirectional Long Short-Term Memory Collaborative Filtering (Bi-LSTM-CF), Bidirectional Encoder Representations from Transformers (BERT), and a hybrid deep learning model to deliver more accurate and context-aware recommendations. By analysing user reviews at a deeper level, it aims to provide a personalized and emotionally intelligent recommendation experience.

The incorporation of Bi-LSTM-CF allows to capture sequential patterns in user behaviour, enhancing the recommendation system's understanding of the evolving preferences of individual users. Collaborative filtering mechanisms complement this approach by tapping into the collective wisdom of user communities, further refining the recommendations.

To address the challenges posed by the unstructured nature of user reviews, BERT, a cutting-edge transformer-based model known for its ability to comprehend contextual information in natural language. BERT's proficiency in understanding the context and sentiment of words in a sentence enables a more nuanced analysis of user reviews, capturing the subtleties that traditional models may overlook. In addition to the individual strengths of Bi-LSTM-CF and BERT, a hybrid deep learning model that synergistically combines the collaborative filtering capabilities of Bi-LSTM with the contextual understanding provided by BERT.

2. Literature Survey

Recommendation systems (RS) have become an essential component of E-commerce platforms, aiding users in navigating vast information spaces and discovering relevant items. The survey investigates recent research trends in RS, with a specific focus on the integration of sentiment analysis and deep learning techniques. There are three foundational approaches to recommendation systems:

- Collaborative Filtering (CF): This technique identifies users with similar preferences and recommends items enjoyed by these similar users. It leverages user-item interaction data, such as ratings or purchase history.
- Content-Based Filtering (CBF): This approach focuses on item attributes and user profiles. It recommends items with similar features to those the user has previously interacted with positively.
- Hybrid Filtering (HF): This approach combines CF and CBF techniques, leveraging the strengths of both. It can address limitations like data sparsity in CF and cold start problems in CBF.

The inclusion of sentiment analysis within recommendation systems offers significant advantages. Customer reviews provide a rich source of user opinions and preferences. By analyzing the sentiment (positive, negative, or neutral) expressed in reviews, recommendation systems can gain a deeper understanding of user preferences and recommend items that better align with their needs. Studies by Rana et al. (2023) [1], Hu et al. (2023) [3], Dang et al. (2022) [5], and Liu et al. (2023) [12] all highlight the benefits of incorporating sentiment analysis into recommendation systems. They propose various deep learning models that exploit sentiment information from reviews to enhance recommendation accuracy.

Deep learning models have emerged as powerful tools for recommendation systems due to their ability to handle complex and high-dimensional data. Convolutional Neural Networks (CNNs) [7, 16, 18] excel at extracting features from images, while Recurrent Neural Networks (RNNs) like LSTMs and BiLSTMs [1, 16] are adept at capturing sequential information in text data like reviews. Several studies within the provided corpus explore deep learning for recommendation systems. Alamdari et al. (2022) [7] propose an image-based recommendation system using CNNs for e-commerce applications. Mutinda et al. (2023) [8] and Bhuvaneshwari et al. (2022) [16] utilize CNNs for sentiment analysis of reviews, while Rana et al. (2023) [1], Iqbal et al. (2022) [17], and Balakrishnan et al. (2022) [18] leverage LSTMs or BiLSTMs for sentiment analysis or recommendation tasks. More recent research delves into transformers like BERT [4, 14, 19, 21]. BERT excels at natural language understanding and can effectively capture the semantic meaning of reviews. Lu et al. (2023) [19] propose BERT-RS, a neural recommender system that leverages BERT for personalized recommendations. Similarly, Channarong et al. (2022) [21] introduce HybridBERT4Rec, a hybrid recommender system that combines BERT with CF and CBF approaches.

The research showcases several exciting advancements in recommendation systems using sentiment analysis and deep learning. Sentiment analysis of user reviews is becoming a crucial component for understanding user preferences and improving recommendation accuracy. Deep learning models like CNNs, LSTMs, and transformers are demonstrating significant potential in extracting meaningful features from reviews and user data for better recommendations. Hybrid models that combine sentiment analysis with traditional CF or CBF approaches are gaining traction to address limitations of individual techniques. By continuing to explore these advancements and addressing the challenges, recommendation systems powered by sentiment analysis and deep learning will become even more effective in personalizing user experiences and driving user engagement in various online applications.

3. Proposed Model

The proposed model used the data source from the E-commerce platform where data is in the form of reviews and ratings on the product.

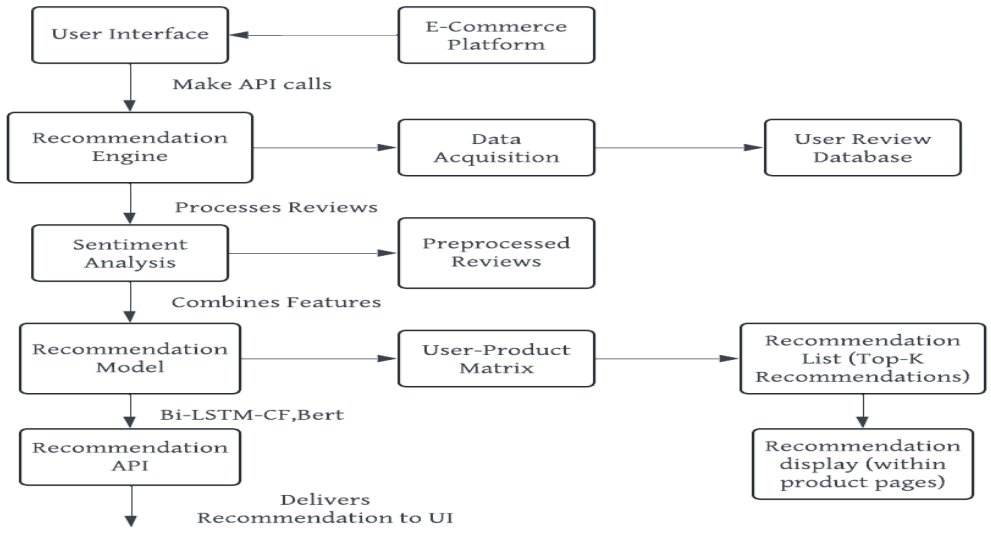


Figure 1. Architecture of the proposed model

The architecture depicts a block diagram outlining a data processing system for sentiment analysis and recommendation.

· User Interface (UI): The interface where users interact with the E-commerce platform. It can include product pages, search bars, and shopping carts. The UI leverages an API to communicate with the recommendation engine.

· E-commerce Platform: The overall E-commerce system that integrates the recommendation engine.

· Recommendation Engine: The core component responsible for generating personalized product recommendations. It consists of several sub-modules:

- Data Acquisition: The module retrieves user reviews from the E-commerce platform's database.
- Sentiment Analysis: The module analyses user reviews to determine the sentiment (positive, negative, neutral) expressed towards each product.
- Preprocessed Reviews: The module cleans and prepares the review data for use in the recommendation model.
- Recommendation Model: The heart of the system, combining LSTM-CF (capturing user-item interactions) and BERT (understanding review context) with sentiment analysis to generate recommendations. The model outputs a user-product matrix with recommendation scores.

· User-Product Matrix: The matrix represents the relationships between users and products, potentially incorporating sentiment scores from the review analysis.

· Recommendation List: Based on the user-product matrix, the system generates a ranked list of recommended products (typically the top K recommendations) for each user.

· Recommendation API: The API serves as the communication bridge between the recommendation engine and the UI. It facilitates the exchange of recommendation information.

· Recommendation Display: Within the E-commerce platform's UI (product pages, etc.), the recommended products are displayed for the user to explore.

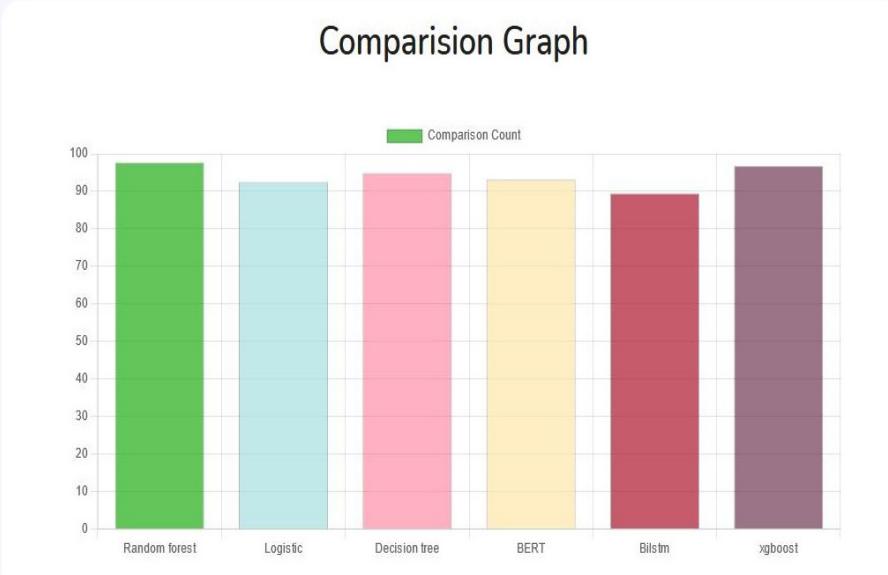
Algorithms Used

i. **LSTM-CF (Long Short-Term Memory Collaborative Filtering):** This approach builds on the traditional collaborative filtering technique. Collaborative filtering recommends items based on the preferences of similar users. LSTM-CF incorporates Long Short-Term Memory networks, a type of recurrent neural network, to analyze user purchase history. Unlike traditional methods that focus on static user data, LSTMs can identify patterns and trends over time. This allows the system to capture evolving user interests and recommend products that align with those changes, making the recommendations more dynamic and relevant.

ii. **BERT (Bidirectional Encoder Representations from Transformers):** This system incorporates BERT, a pre-trained language model that excels at understanding the complexities of human language. BERT goes beyond simply identifying keywords in user reviews. It delves deeper to extract sentiment and contextual meaning. By understanding the emotions and opinions expressed in reviews, the system can refine its recommendations to better align with user preferences. For instance, if a user leaves a critical review about a specific feature of a product, BERT can ensure similar products with improved features are recommended.

iii. **Hybrid Deep Learning:** The magic lies in how these algorithms work together. This system utilizes hybrid deep learning, which essentially combines the strengths of LSTM-CF and BERT. LSTM-CF captures user behavioral patterns and preferences over time. BERT analyzes the emotional context from user reviews. By combining these insights, the system can generate highly personalized recommendations that consider past purchases, evolving preferences, and the sentiment expressed in user reviews. This comprehensive approach leads to more accurate and relevant product suggestions for each user.

4. Results



The comparison graph between Random Forest (98.43), Logistic Regression (92.65), Decision Tree (92.65), BERT (93.15), BiLSTM (89.53), XGBoost (97.11) on the accuracy driven for the models of reviews.

5. Conclusions

In conclusion, leveraging deep sentiment analysis on user reviews on E-Commerce products holds significant potential for enhancing the recommendation system on the platform. By analysing the sentiments expressed in user reviews, it can better understand the preferences and opinions of its customers, leading to more accurate and personalized product recommendations. The experiment carried

out on machine learning algorithms like Random Forest, Decision Tree, XG-Boost and Logistic Regression performed on an average basis giving accuracy of 98.43%, 92.65%, 97.11% and 92.65% respectively. Whereas pretrained models like BERT and Bi-LSTM give accuracy on the higher side; giving accuracy of 93.15% and 89.53% respectively. Support vector machine algorithm manages to give higher accuracy of up to 97% making it most efficient for use for recommendation on user reviews.
Future work can delve into exploring methods for explainable sentiment analysis. Understanding how their expressed emotions and opinions are reflected in the suggested products can further enhance user acceptance and trust in the system. This transparency can foster trust and user confidence in the system, ultimately leading to a more positive user experience. It is crucial to investigate potential biases that might exist within the recommendation system due to user review data or the chosen deep learning algorithms. Future research can focus on developing techniques to identify and mitigate these biases, ensuring that the system delivers fair and unbiased recommendations for all users, regardless of background or past behaviour.

References

[1] Rana, Muhammad Rizwan Rashid, et al. "A BiLSTM-CF and BiGRU-based Deep Sentiment Analysis Model to Explore Customer Reviews for Effective Recommendations." Engineering, Technology & Applied Science Research 13.5 (2023): 11739-11746.
[2] Wijaya, I. Wayan Rizky. "Development of a conceptual model to increase customer interest using a recommendation system in e-commerce." Procedia Computer Science 197 (2022): 727-733.
[3] Hu, Limei, Chunqia Tan, and Hepu Deng. "Product recommendation using online reviews with emotional preferences." Kybernetes 52.5 (2023): 1573-1596
[4] Seol, Jinseok Jamie, Youngrok Ko, and Sang-goo Lee. "Exploiting Session Information in BERT-based Session-aware Sequential Recommendation." Proceedings of the 45th International ACM SIGIR Conference on Research and Development in Information Retrieval. 2022.
[5] Dang, Elliot, Zheyuan Hu, and Tong Li. "Enhancing collaborative filtering recommender with prompt-based sentiment analysis." arXiv preprint arXiv:2207.12883 (2022).
[6] Torbati, Ghazaleh Haratinezhad, et al. "Recommendations by Concise User Profiles from Review Text." arXiv preprint arXiv:2311.01314 (2023).
[7] Alamdari, Pegah Malekpour, et al. "An image-based product recommendation for E-commerce applications using convolutional neural networks." Acta Informatica Pragensia 11.1 (2022): 15-35.
[8] Mutinda, James, Waweru Mwangi, and George Okeyo. "Sentiment analysis of text reviews using lexicon-enhanced bert embedding (LeBERT) model with convolutional neural network." Applied Sciences 13.3 (2023): 1445.
[9] Hannan, Shaikh Abdul, et al. "Data Mining and Natural Language Processing Methods for Extracting Opinions from Customer Reviews." International Journal of Computational Intelligence and Information Security: 52-58.
[10] Iwendi, Celestine, et al. "Pointer-based item-to-item collaborative filtering recommendation system using a machine learning model." International Journal of Information Technology & Decision Making 21.01 (2022): 463-484.
[11] Chamekh, Ameni, Mariem Mahfoudh, and Germain Forestier. "Sentiment analysis based on deep learning in e-commerce." International Conference on Knowledge Science, Engineering and Management. Cham: Springer International Publishing, 2022.
[12] Liu, Ning, and Jianhua Zhao. "Recommendation system based on deep sentiment analysis and matrix factorization." IEEE Access 11 (2023): 16994-17001.
[13] Xiao, Bohuai, et al. "RTN-GNNR: Fusing Review Text Features and Node Features for Graph Neural Network Recommendation." IEEE Access 10 (2022): 114165-114177.
[14] Bilal, Muhammad, and Abdulwahab Ali Almazroi. "Effectiveness of fine-tuned BERT model in classification of helpful and unhelpful online customer reviews." Electronic Commerce Research 23.4 (2023): 2737-2757.

[15] Kutlimuratov, Alpamis, et al. "Modeling and applying implicit dormant features for recommendation via clustering and deep factorization." Sensors 22.21 (2022): 8224.
[16] Bhuvaneshwari, P., et al. "Sentiment analysis for user reviews using Bi-LSTM self-attention-based CNN model." Multimedia Tools and Applications 81.9 (2022): 12405-12419.
[17] Iqbal, Amjad, et al. "Sentiment analysis of consumer reviews using deep learning." Sustainability 14.17 (2022): 10844.
[18] Balakrishnan, Vimala, et al. "A deep learning approach in predicting products' sentiment ratings: a comparative analysis." The Journal of Supercomputing 78.5 (2022): 7206-7226.
[19] Lu, Kezhi, et al. "BERT-RS: A neural personalized recommender system with BERT." Machine Learning, Multi Agent and Cyber Physical Systems: Proceedings of the 15th International FLINS Conference (FLINS 2022). 2023.
[20] Elahi, Mehdi, et al. "Hybrid recommendation by incorporating the sentiment of product reviews." Information Sciences 625 (2023): 738-756.
[21] Channarong, Chanapa, et al. "HybridBERT4Rec: a hybrid (content-based filtering and collaborative filtering) recommender system based on BERT." IEEE Access 10 (2022): 56193-562.

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