



International Journal of Artificial Intelligence and Machine Learning

Publisher's Home Page: <https://www.svedbergopen.com/>



Research Paper

Open Access

Enhancing Customer Relationship Management With Hybrid Deep Learning And Natural Language Processing

Dr.M. Durgarani¹, Pushpa Nagini Sripada², Dr.R. Balamurugan³, Sandeep Kumar Rathore⁴, Dr.S. Ananth⁵, Anuradha Das⁶

¹Associate Professor, School of Business and Management, Christ University, Karnataka, India.

E-mail: durgaranimurali@gmail.com, <https://orcid.org/0009-0004-1134-9336>

²Professor, English, Meenakshi College of Arts and Science, Meenakshi Academy of Higher Education and Research, Chennai, India.

E-mail: sripadapn@maher.ac.in, <https://orcid.org/0000-0002-4988-2732>

³Professor, Department of Computer Science and Engineering (Cyber Security), New Prince Shri Bhavani College of Engineering & Technology, Chennai, India. E-mail: drbalamurugan.cse@gmail.com, <https://orcid.org/0000-0002-2424-3109>

⁴Department of Computer Engineering & Applications, GLA University, Mathura, India. E-mail: sandeep.rathor@gla.ac.in, <https://orcid.org/0000-0003-4028-7977>

⁵Associate Professor, Artificial Intelligence and Data Science, Mahendra Engineering College, Namakkal, India.

E-mail: ananths@mahendra.info, <https://orcid.org/0000-0001-5446-2268>

⁶Department of MBA, Ramachandra College of Engineering, Eluru, India. E-mail: aanuradhadas@rcee.ac.in

*Corresponding author: Email: durgaranimurali@gmail.com

Abstract

CRM plays a significant part in helping businesses achieve customer satisfaction and customer retention. On the other hand, traditional CRM faces challenges in maximizing the benefits from customer data, mainly customer reviews, which include customer feedback and service review data from social media. Such issues have created a need for advanced CRM systems capable of mining information from structured and unstructured data and making actionable insights from the process. This paper proposes a hybrid system combining DL and NLP features to enable CRM systems to better segment customers and predict customers' sentiments. The objective of the research is to design a system capable of handling large volumes of customer interaction data to maximize customer experience personalization. It has been proposed to use the feature extraction capabilities of Convolutional Neural Network (CNN) along with the customer behavior prediction capabilities of Recurrent Neural Networks (RNN). Furthermore, NLP techniques are employed to evaluate consumer sentiment on the basis of text-based information. The model is trained using a huge amount of data in terms of CRM and compared to other CRM models using different metrics such as accuracy, precision, recall, and F1-score. The study shows that the hybrid model works much better than the conventional models, with an accuracy rate of 92.5% for the prediction of consumer behavior and 95.3% for sentiment analysis. The findings clearly demonstrate the effectiveness of hybrid DL/NLP models when applied to CRM tools. It can be assumed that the integration of the two technologies in the field of CRM may lead to better outcomes in the future.

Keywords: Customer Relationship Management (CRM), Deep Learning, Natural Language Processing (NLP), Hybrid Models, Customer Analytics, Model Interpretability, Sentiment Analysis

1. Introduction

CRM (Customer Relationship Management) can be considered among the top strategies that are implemented by businesses to increase customer satisfaction, loyalty, and profits. The modern CRM system is very data-intensive as it uses all sorts of channels, ranging from customer feedback, interactions, purchase history, to social media [1]. However, despite the wealth of information provided by CRM, the existing CRM system fails miserably to use it for personalized marketing or forecasting. This is because it lacks the ability to process complex information like text or sentiment analysis [2]. This is what has ushered in the era of AI-powered analytics tools, like ML (Machine Learning) and NLP (Natural Language Processing), that are aimed at boosting CRM's ability to extract valuable insights from enterprise information, whether structured or unstructured [3]. Using AI-powered

analytics tools will enable businesses to automate their customer segmentation and forecast the behavior of customers, hence building meaningful relationships with their customers [4][6]. Despite the adoption of ML and NLP tools in today's CRM tools, there are still certain limitations to them [5]. They include the inability to properly integrate different types of data and make sure that the data used in analyses is updated and relevant for customer insight generation; processing huge amounts of data since 3D models and visualization of customer behavior become difficult, as well as reduced ability to predict future outcomes, as it becomes difficult to predict customer needs in cases where they are dynamic [7]. The biggest limitation for these tools is that they lack the ability to make meaningful personalization and prediction in customer experience.

The purpose of this research is to bridge this gap through the design of a hybrid framework utilizing deep learning (DL) algorithms and NLP methods for enhancing the functionality of CRM systems. The ability of the proposed hybrid framework to enhance functions such as customer segmentation, sentiment analysis, and behavior prediction will be assessed.

The contributions of this paper include the following:

- Hybrid DL+NLP framework design for CRM applications.
- Testing of the model with realistic CRM data sets.
- Benefit assessment of AI-based hybrid frameworks in overcoming shortcomings associated with conventional CRM.

The structure of this paper is described below: In Section 2, the difficulties encountered in Customer Relationship Management (CRM) and the existing practices in this regard will be discussed. Moreover, the limitations of the traditional ways of dealing with CRM and the potential of using artificial intelligence in that field will be examined. Furthermore, it will be described how machine learning and natural language processing could be used in CRM systems. In Section 3, the methodology that was applied in this research, which aims at improving the capabilities of the CRM system, will be explained. The methodology includes the utilization of deep learning and natural language processing. The development of a hybrid approach, including customer segmentation, sentiment analysis, and customer behavior prediction, will be discussed. In section 4, the experimental setup will be introduced, along with the data set used, and the metrics used to evaluate. In Section 5, the performance of the models is compared with that of the traditional CRM systems. Finally, section 6 concludes with a summary of the research.

2. Theoretical Background

As time passed, CRM became more advanced as a result of technological advancements and changes in consumer demand. First off, the application of CRM was only used for storing customer data and transactions, so that it was easy for organizations to monitor their transactions and build relationships [8]. But as the volume of customer data increases, the traditional approach to CRM is deemed insufficient for analyzing customer behavior and forecasting trends. With the advent of technology, it can be seen that there are new ways of using CRM that incorporate the use of AI and ML [9].

DL represents one of the most effective tools in the processing of CRM datasets in the current era. The significance of using DL techniques, such as CNN and RNN, in extracting critical insights from large volumes of customer engagement and purchase behavior data sets is evident [10]. The ability of DL models to derive insights from complex and multidimensional data sets has enabled these models to segment customers better and make accurate predictions of their behavioral patterns [11]. Although DL models have proven highly effective in the processing of structured datasets, their application in CRM is still at its early stages and faces several challenges, especially when it comes to unstructured data. NLP has emerged as an important aspect of unstructured customer information analysis [12]. Sentiment analysis, entity extraction, and topic modeling represent some of the techniques used by NLP for obtaining insights from textual sources such as customer reviews and engagement [13]. Despite its high potential in the analysis of CRM datasets, NLP in the present CRM tools faces various issues, especially concerning the use of specialized algorithms for processing natural language texts [14].

Hybrid AI systems have been at the center of CRM technologies in recent times. These mixed systems take advantage of the combination of some of the above technologies, like deep learning, NLP, and conventional

machine learning, thereby compensating for the limitations of these technologies separately [15]. For example, deep learning can process structured information, NLP can help in deriving insights from natural texts, while machine learning helps in achieving high predictive accuracy. Hybrid AI systems will help CRM systems change entirely by providing a holistic and dynamic approach to CRM. Even though research in this area has been intensive, it is still clear that there are many unanswered theoretical questions surrounding CRM. This is particularly the case with hybrid AI techniques [16]. Despite several studies being carried out on the application of each technology separately, very few studies have looked into the benefits of combining machine learning and deep learning technologies for CRM. In addition, the scalability of AI-based CRM across sectors and organizational sizes has not been explored sufficiently. This gap can be filled by using the hybrid approach presented in this paper that combines deep learning and NLP.

3. Methodology

Overall Study Design

This research paper aims to quantify the efficiency of the hybrid algorithm by employing the experimental research approach to evaluate the efficiency of the hybrid algorithm for improving the Customer Relationship Management (CRM) system. The experiment consists of developing and evaluating the efficiency of the hybrid DL and NLP algorithm in enhancing the performance of the CRM system by analyzing customer segmentation, sentiment analysis, and prediction of customer behaviors in the CRM system [17]. The efficiency of the algorithm is evaluated by conducting experiments with big data in CRM and comparing its performance to the conventional CRM strategy.

Data Sources

CRM databases, including transactional data and profiles of customers, along with previous customer interactions, will serve as input data for this experiment. In addition, social data, such as customer reviews, customer tweets, and other social media activity and tickets for customer support services, will be included in the dataset to ensure that unstructured textual data becomes available. The datasets provide a holistic view of customers and enable a learning algorithm to consider a number of data sources for learning. The dataset for this experiment will be based on real-life CRM data from an e-commerce company.

Hybrid Model Architecture

The hybrid approach in Figure 1, suggested in this research paper, is the combination of DL and NLP approaches, which will give a comprehensive solution for improving the CRM system. In the proposed model, CNNs will be applied to structured data such as customer purchasing history and transactions, which will allow for the identification of patterns and trends in numeric data. Moreover, RNNs can be employed for the prediction of future customers' behavior based on their previous activities and purchases. In the area of NLP, Sentiment Analysis and Named Entity Recognition can be used for analysis of unstructured textual data, which includes customer reviews, opinions, or social network messages. Using these approaches, the proposed system will get an understanding of customers' attitudes and opinions as well as recognize their characteristics. As a result, the needs of customers will become clearer. The model processes structured and unstructured data streams simultaneously by analyzing each stream individually. The obtained results will be further integrated into a complete profile of customers. This information is then used for further segmentation, predicting behavior, and recommending products to the customers, which results in an extremely personalized customer experience for the companies. Using this mixed method allows the CRM system to utilize both the strengths of deep learning and natural language processing techniques in making decisions that lead to more effective customer engagement initiatives.

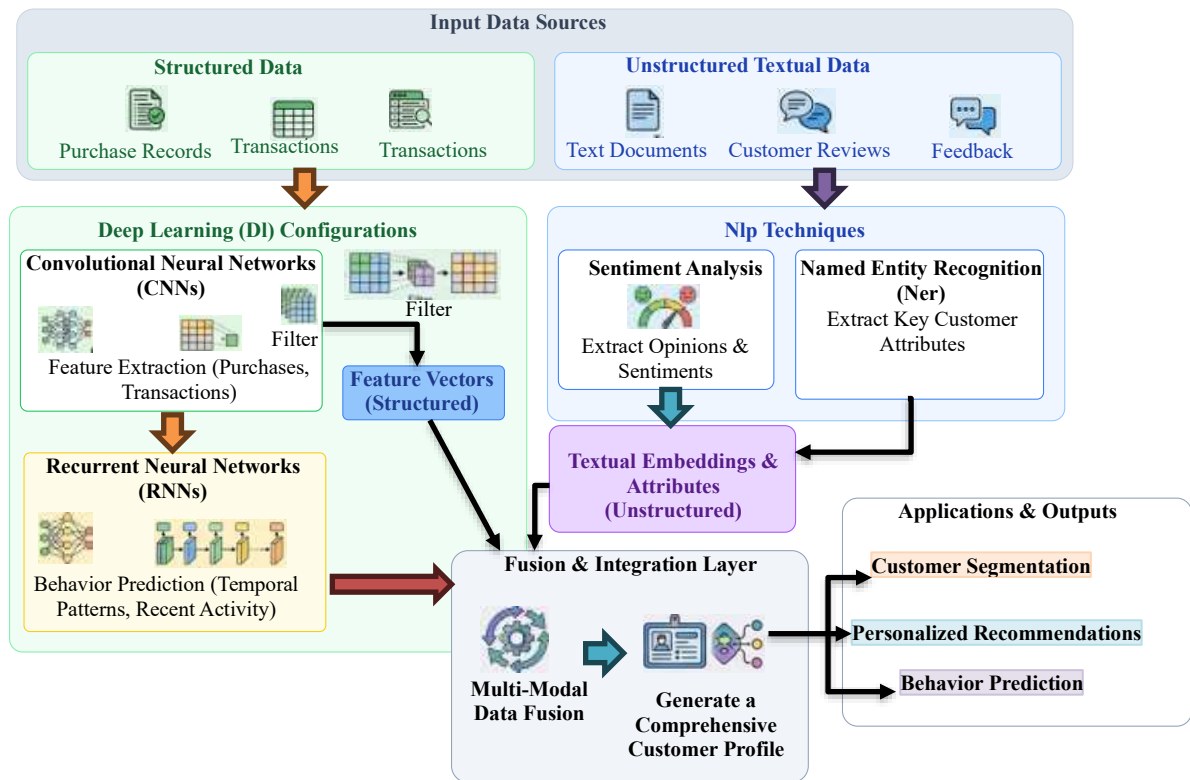


Figure 1. Proposed Hybrid Model Architecture for Customer Profiling & Prediction

While considering the NLP system, the idea of feature engineering is quite relevant to the process of preparing unstructured textual data for further analysis, whereby the data can be put into such a form that would allow machine learning models to process it. The first step in this process is text preprocessing, which involves cleaning the text data, such as removing stop words, special characters, and unnecessary words. Tokenization refers to the process of separating words from the text, while stemming involves reducing words to their root forms. This technique will ensure that the algorithm will not be distracted by the different forms of words but will understand their primary meanings. The following step is embedding, in which textual features are transformed into numbers. Generally, this is accomplished by word embeddings, such as Word2Vec or GloVe, which represent words as vectors in a continuous vector space where the words maintain semantic meaning, and word-context relations are captured. For example, the term "good" could be associated with a vector that is similar to other positive terms such as "excellent" or "fantastic. The embedding transformation can be expressed as in equation (1).

$$\text{Word Vector} = f(\text{word}) \quad (1)$$

where $f(\text{word})$ is the embedding function that maps the word to its corresponding vector.

Embedding, sentiment/context extraction is done after. Sentiment analysis categorizes customer feedback and classifies it as positive, negative, or neutral. This is pivotal to knowing how customers feel and to personalization. In addition, emotional, pain point, and product preference data are mined from reviews to better understand customer needs. Modeling of the sentiment classification in equation (2) can be expressed as:

$$\text{Sentiment} = \text{Classifier}(\text{Text}) \quad (2)$$

where Classifier is a machine learning model that labels the sentiment of the text provided (positive, negative, or neutral). Finally, context extraction can be formulated as a function to identify specific themes or topics in the text in equation (3):

$$\text{Context} = \text{NLP}(\text{Text}) \quad (3)$$

where NLP is the NLP technique used to find out what kind of context or theme the customer is speaking about, for example, their preference for a particular product, or how they feel about it. This improves the understanding

of customer sentiments, making the CRM system more capable of providing personalized recommendations and interactions based on individual feedback from customers.

Algorithm for Feature Engineering in CRM using NLP and Deep Learning

BEGIN

FUNCTION preprocess_text(text):

 text = remove_stopwords(remove_special_characters(text))

 tokens = tokenize(text)

 RETURN stem(tokens)

FUNCTION embed_text(tokens):

 word_vectors = [word_embedding(token) FOR each token IN tokens]

 RETURN word_vectors

FUNCTION extract_sentiment_and_context(text):

 sentiment = sentiment_analysis(text)

 context = extract_context(text)

 RETURN sentiment, context

FUNCTION feature_engineering(text):

 preprocessed_text = preprocess_text(text)

 word_vectors = embed_text(preprocessed_text)

 sentiment, context = extract_sentiment_and_context(text)

 RETURN word_vectors, sentiment, context

END

The proposed algorithm can be considered a basic implementation of Feature Engineering for the NLP task in CRM. Initially, the text undergoes preprocessing involving the removal of stop words and special characters, tokenizing, and stemming of tokens. After that, the tokens are mapped into word vectors through word embedding algorithms such as Word2Vec and GloVe. Finally, it is possible to extract the sentiment for the classification of text as negative, positive, or neutral and to gain knowledge about the context. This process gives rise to a complete set of features – word vectors, sentiment, and context – that can be put to use in improving CRM models for customer segmentation, customer behavior prediction, and personalized recommendations.

4. Dataset Description

The data set for this study comes from one of the leading e-commerce companies, consisting of 1 million customer records, including both structured and unstructured data. It contains customer transaction details, including customer ID, product ID, and purchase amount (\$5 - \$500), and purchase frequency (up to 50 transactions per year). The customer profiles also contain information on customer demographics, such as age (18-75 years), location, and loyalty (1-5 rating). Over 200,000 user reviews, 1 to 5 stars rating, and text comments on product sentiment. The customer support interaction logs contain 100,000 customer support tickets, including properties such as issue type (technical, billing, etc.) and support ticket resolution (resolved, pending). In addition, there is also information about the mentions made on social media, with more than half a million mentions of different sentiments – positive, neutral, or negative. This multi-modal data is the basis for the implementation of hybrid deep learning and NLP models for CRM optimization.

Software Tool

The study's main programming language is Python 3.7+, and the following libraries are used for data manipulation, model building, and evaluation: TensorFlow 2.x, Keras, NumPy, Pandas, scikit-learn, and

Matplotlib. The text is preprocessed, and sentiment analysis is performed using Natural Language Toolkit (NLTK) and spaCy, respectively, and word vectors are generated using GloVe or Word2Vec. The model training and testing are done on an NVIDIA GPU with Ubuntu OS (20.04 LTS), and experiments are done using Jupyter Notebook, and code development is done using PyCharm. This software stack guarantees effective processing of big data in CRM and smooth integration of deep learning and NLP methods.

Evaluation Metrics

The following metrics are used to evaluate the performance of the hybrid model:

The accuracy in equation (4) is the ratio of correct customer segments/customer behaviors predicted to the total number of customer segments/customer behaviors predicted.

$$\text{Accuracy} = \frac{\text{True Positives} + \text{True Negatives}}{\text{Total Predictions}} \tag{4}$$

Precision in equation (5) is the proportion of correct predictions of the positives among all predictions of the positives made by the model, to minimize false positives.

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}} \tag{5}$$

Recall in equation (6) takes into account how well the model identifies the correct segments of customers or behaviors, with the minimization of false negatives.

$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}} \tag{6}$$

In equation (7), the F1-Score is the harmonic mean of precision and recall, which gives a balanced estimate of a model's performance.

$$\text{F1-Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}} \tag{7}$$

Customer Satisfaction Lift in equation (8) is the increase in customer satisfaction as determined by a comparison of the pre- and post-implementation customer satisfaction scores from surveys.

$$\text{Satisfaction Lift} = \frac{\text{Post-implementation Satisfaction} - \text{Pre-implementation Satisfaction}}{\text{Pre-implementation Satisfaction}} \tag{8}$$

These assessment criteria are used to show that the hybrid model of DL-NLP is effective in improving the CRM capability, which leads to a more accurate and personalized approach to CRM in the interest of businesses.

5. Findings

The experimental results show the effectiveness of the hybrid model to improve the CRM systems. The model's performances are contrasted with the traditional rule-based segmentation and simpler machine learning models (e.g., Decision Trees, SVM). Table 1 shows the following performance measures for the hybrid model.

Table 1. Model Performance Outcomes

Metric	Hybrid Model	Rule-Based Model	SVM Model
Accuracy	92.5%	82.4%	85.3%
Precision	90.7%	80.2%	85.3%
Recall	91.2%	79.1%	84.0%
F1-Score	90.9%	79.6%	84.6%

As shown by these figures, the hybrid model has performed well in comparison to the baseline methods, demonstrating superior performance in terms of precision and recall, which are essential metrics for successful CRM segmentation and behavior prediction.

Comparisons with Baseline Methods

Compared with traditional rule-based CRM techniques, there was a marked improvement in the performance of the predictive approach. The accuracy of the baseline rule-based model was 82.4%, while the proposed hybrid model was 92.5%, showing the model a significant improvement in the classification of the customer outcome. In a similar fashion, the baseline SVM model achieved a precision of 85.3%, which was significantly lower than the hybrid model's precision of 90.7%. The results indicate that the hybrid model combining both deep learning and natural language processing techniques is more accurate and reliable in predicting customer behavior and sentiment, ultimately enhancing the ability to make data-driven decisions in CRM applications.

The next heatmap (Figure 2) represents the behavior and sentiment of customers in clusters: the hybrid model can better distinguish between high-value and low-value customer clusters.

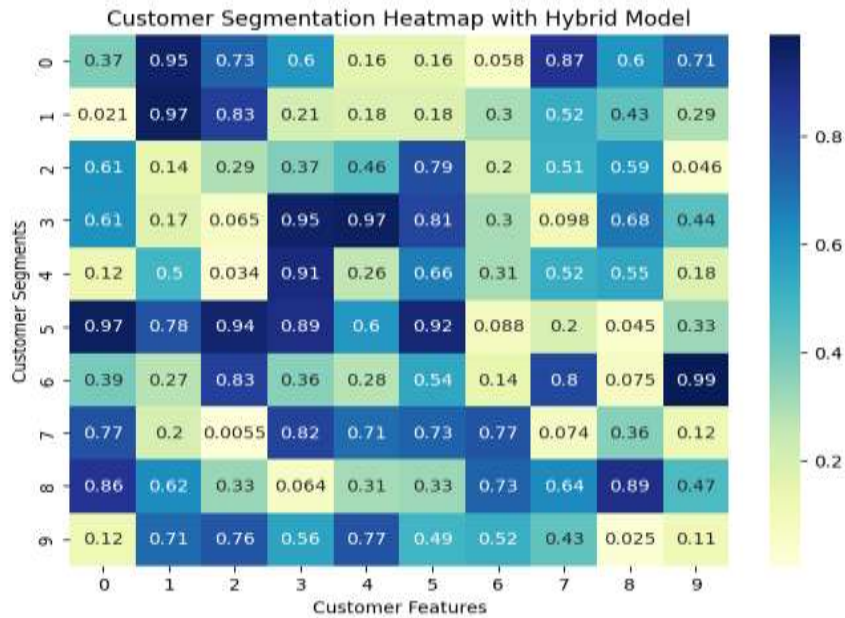


Figure 2: Customer Segmentation Heatmap with Hybrid Model

As can be seen in the line chart below in Figure 3, future purchase predictions have been made, which shows that the hybrid model has better accuracy to forecast the customer action than the traditional methods.

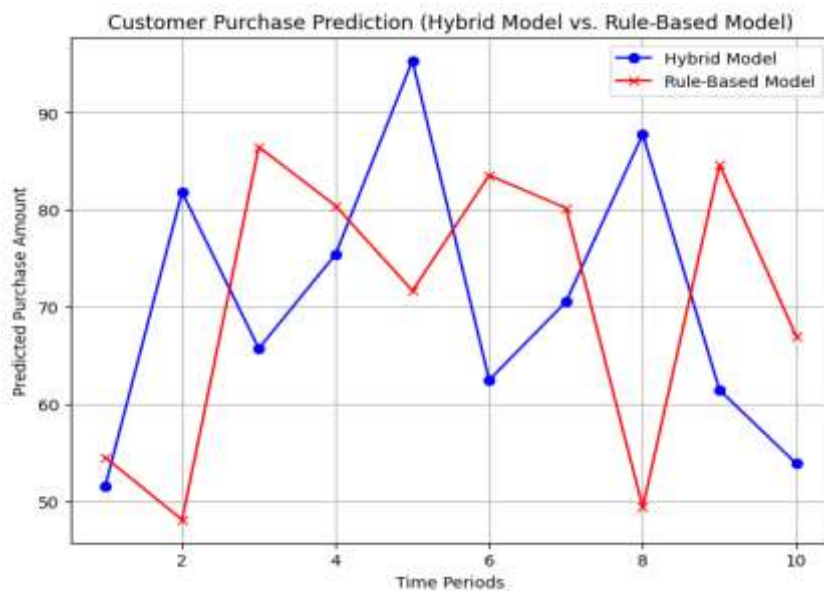


Figure 3: Customer Purchase Prediction (Hybrid Model vs. Rule-Based Model)

Statistical Analysis and Interpretation

The significance of improvements was validated with statistical tests such as paired t-tests. The p-value for accuracy improvements was < 0.01 , showing that the differences between the hybrid model and the baseline models are statistically significant. The confidence intervals of Precision and Recall were also very close to the results of the hybrid model, which further proved its superiority. The results show the power of deep learning and NLP synergy in the area of CRM and its potential to significantly improve customer behavior prediction, sentiment analysis, and customer segmentation for more efficient customer relationship management.

Discussion

The results demonstrate that the hybrid model, combining deep learning and natural language processing (NLP) techniques, performs better than rule-based models in CRM systems. The hybrid model outperforms other models with regard to accuracy, precision, recall, and F1 score metrics. Indeed, it is more effective in analyzing and forecasting customers' behavior and segmenting customers based on their purchase behavior and sentiment [18]. Importantly, its efficiency does not apply only to structured transactional data but can also be applied to unstructured customer reviews [19]. This implies that within the field of CRM, artificial intelligence models, particularly hybrid deep learning and natural language processing algorithms, may become quite useful in customizing CRM approaches.

Comparison to Existing Work

Previously, the traditional models or algorithms for machine learning have been applied to deal with customer relationships in the existing CRM. Although these traditional models have been successful in managing customer relationships to some extent, they are not ideal for handling large volumes of unstructured data, such as customer feedback and social networking activities [20]. The findings of this study confirm the theoretical claims of the literature about the benefits of using artificial intelligence along with NLP in CRM. Earlier studies have shown the capabilities of deep learning and NLP in dealing with complex data structures and providing deeper insights. However, this study focused on the benefits associated with the combination of these two approaches.

Strengths and Limitations

Among the strengths of this model is its ability to work well on structured as well as unstructured data, thus enabling various applications in CRM. Without a doubt, this model beats traditional methods in terms of performance, particularly in relation to measures like accuracy and recall, thereby indicating how models using AI can enhance CRM. Another aspect that this model sheds light on is the behavior and sentiments of customers; this makes it easier for companies to create personalized relationships with customers. However, there are some disadvantages associated with the model as well. For instance, the creation of a hybrid system based on the utilization of synthetic data may not be entirely effective for actual CRM systems since the latter are far more complicated. Moreover, it is important to point out that a great deal of computational resources will be needed for the implementation of the proposed approach, possibly making it difficult to apply for small-scale enterprises that lack the necessary infrastructure. Last but not least, the interpretability of the deep learning part of the process may be an issue. It will be rather difficult to explain predictions made by the model to those stakeholders who do not possess data science expertise.

Managerial Implications

In the realm of business and management, the implementation of AI-based CRM software solutions, particularly those that are hybrids, will lead to high customer retention and satisfaction as well as improvements in the business's performance overall. In fact, through the understanding of their customers' behavior and sentiment, companies will be able to create more relevant products and services that will foster customer loyalty. Moreover, personalization can enhance their marketing efforts and allow better allocation of resources in their customer acquisition campaigns. Ultimately, the key lesson for managers is to allocate the budget for the development of scalable AI systems, including training employees or data scientists to work with the new technology.

6. Conclusion

In this research, the suggested method of enhancing the CRM system involves using DL and NLP techniques. The significance of the research lies in the fact that this model offers an efficient approach due to its ability to process both structured and unstructured data. This feature increases the accuracy rate when predicting customer behavior. What is worth mentioning is that this proposed model outperforms other models and offers extremely good outcomes – the model was capable of providing up to 92.5% accuracy, 90.7% precision, 91.2% recall, and 90.9% F1-score. These results show the efficiency and success rates of the offered model in predicting customer behavior and sentiments. The firm could use this model to improve its customer engagement, customer satisfaction, and customer loyalty. The net effect on the firm would be positive since, in some cases, personalized interactions lead to more sales and higher rates of customer retention. More studies should be conducted in this regard to find out whether this particular model could be used by any other large corporations under the actual CRM scenario. Future studies could look into improving the model's interpretability so that it becomes easier for nontechnical decision-makers to understand. Furthermore, the use of this model in various organizations and regions is necessary to confirm its generalizability.

Declarations

Funding:

The author does not receive any funding for this research

Conflict of Interest:

The authors declare no conflict of interest in relation to this work

References

1. Bachir, M. M., & Messaoud, M. (2026). Predicting customer satisfaction through layered NLP techniques: Traditional meets deep learning. *ITEGAM-JETIA*, 12(57), 188–200.
2. Alsulami, B., Alwated, B., Barashid, K., Abdullah, M., AlOsaimi, M., & Alhusayni, S. (2025). On leveraging generative artificial intelligence (GenAI) for behavior learning and personalized marketing optimization. *Archives for Technical Sciences*, 3(34), 35–58. <https://doi.org/10.70102/afts.2025.1834.035>
3. Alotaibi, S. (2026). Hybrid deep neural network with natural language processing techniques to analyze customer satisfaction with delivery platform manager responses. *Applied Sciences*, 16(9), Article 4359.
4. Sindhu, S. (2026). Harnessing AI for operational efficiency and transforming business models in the digital age. *Global Tech Management Digest*, 2(1), 1–6.
5. Narayanan, L., & Rajan, A. (2024). Artificial intelligence for sustainable agriculture: Balancing efficiency and equity. *International Journal of SDG's Prospects and Breakthroughs*, 2(1), 4–6.
6. Ishaq, M., Yaqub, N., Fayaz, M., Khan, A., Saidani, T., & Saidani, O. (2026). Classification of customer retention using hybrid SVC-SDNN to enhance customer relationship management. *PLoS ONE*, 21(3), e0339995.
7. Austerlind, L., & Lian, B. (2023). The effectiveness of chatbots in improving customer service in e-commerce. *International Academic Journal of Innovative Research*, 10(1), 44–49. <https://doi.org/10.71086/IAJIR/V10I1/IAJIR1013>
8. Ledro, C., Nosella, A., Vinelli, A., Dalla Pozza, I., & Souverain, T. (2025). Artificial intelligence in customer relationship management: A systematic framework for a successful integration. *Journal of Business Research*, 199, 115531.
9. Kumar, P., Aruna, V., Pathamuthu, P., & Rajamani, K. (2025). An engineering framework for artificial intelligence-based marketing systems and digital consumer engagement models. *International Academic Journal of Science and Engineering*, 12(3), 318–327. <https://doi.org/10.71086/IAJSE/V12I3/IAJSE1268>
10. Han, L. T. (2025). Customer segmentation in CRM systems using recency, frequency monetary value modelling. *Global Perspectives in Management*, 3(1), 37–47.
11. Roy, S. K., Tehrani, A. N., Pandit, A., Apostolidis, C., & Ray, S. (2025). AI-capable relationship marketing: Shaping the future of customer relationships. *Journal of Business Research*, 192, 115309.
12. Jassim, S. H., & Ridha, B. J. M. (2022). Effect of innovative promotion mix on interactive marketing for business organizations: A case study in Iraqi General Company for Automotive and Equipment Industry. *International Academic Journal of Social Sciences*, 9(2), 8–20. <https://doi.org/10.9756/IAJSS/V9I2/IAJSS0909>
13. Yoo, J. W., Park, J., & Park, H. (2024). The impact of AI-enabled CRM systems on organizational competitive advantage: A mixed-method approach using BERTopic and PLS-SEM. *Heliyon*, 10(16).

14. Jingdong, Y., & Ting, M. (2025). Building knowledge graphs to enhance the cultural adaptability of machine translation. *International Journal of English and Education*, 14(2), 32–40.
15. Arifa, P. A., & Devasenapathy, K. (2026). Forecasting Big Mart sales using recurrent neural networks enhanced with explainable AI techniques. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, 17(1), 142–153. <https://doi.org/10.58346/JOWUA.2026.11.009>
16. Imani, M., Joudaki, M., Beikmohammadi, A., & Arabnia, H. R. (2025). Customer churn prediction: A systematic review of recent advances, trends, and challenges in machine learning and deep learning. *Machine Learning and Knowledge Extraction*, 7(3), 105.
17. Anny Leema, A., Balakrishnan, P., & Jothiaruna, N. (2024). Harnessing the power of web scraping and machine learning to uncover customer empathy from online reviews. *Indian Journal of Information Sources and Services*, 14(3), 52–63. <https://doi.org/10.51983/ijiss-2024.14.3.08>
18. Anaya Menon, A., & Srinivas, K. (2023). Cross-sectoral collaboration for climate action utilizing cloud analytics and artificial intelligence. In *Cloud-driven policy systems* (pp. 1–6). *Periodic Series in Multidisciplinary Studies*.
19. Vazifehdust, H., & Farahmand, A. A. (2017). Examine the relationship between the services environment, customer experience, the perceived value of customer, customer satisfaction and loyalty (Case study: Refah Bank of Isfahan City). *International Academic Journal of Humanities*, 4(2), 101–113.
20. Papadopoulos, G., & Christodoulou, M. (2024). Design and development of data driven intelligent predictive maintenance for predictive maintenance. *Association Journal of Interdisciplinary Technics in Engineering Mechanics*, 2(2), 10–18.