

Research Article

A Graph-Enhanced Approach for Consumer Sentiment Analysis

Kanuri Raghu¹, Kanuri Harsha Vardhan²

¹Assistant Professor, Ramachandra College of Engineering, Eluru, AP

² Student, Department of Computer Science, Koneru Lakshmaiah Deemed to be University,
Vijayawada, AP

Corresponding Author: Kanuri Raghu.

Abstract

Understanding how customers feel is essential for online businesses, but deciphering written reviews can be incredibly complex. Older text analysis tools often fail to grasp the true meaning behind customer feedback, especially when shoppers use sarcasm, mixed emotions, or mention several different product features in a single sentence. This article presents a new approach using Graph-Enhanced Transformers to evaluate customer sentiment in the e-commerce sector. Transformer models are highly effective at reading the natural flow and context of sentences, while graph models excel at mapping the relationships between different ideas. By bringing these two technologies together, our proposed framework can accurately connect a specific customer emotion directly to a specific product detail. This combined method adapts easily to the casual and dynamic way people type online, successfully overcoming the limitations of traditional systems. Ultimately, this research demonstrates that blending graph structures with advanced language models gives digital retailers a much clearer, more reliable picture of true consumer sentiment.

Keywords: Graph Neural Networks (GNN), Natural Language Processing (NLP), Sentiment Analysis, E-Commerce, Consumer Behavior, Product Reviews, Aspect-Based Sentiment.

1. Introduction

In recent years, e-commerce has become an essential part of modern life, changing the way people buy products and services. Online platforms provide convenience, variety, and accessibility, allowing customers to shop from anywhere at any time. Along with this rapid growth, there has been a significant increase in user-generated content such as product reviews, ratings, and feedback. These reviews play a crucial role in influencing purchasing decisions and help businesses understand customer satisfaction and expectations.

Customer reviews contain valuable information about product quality, delivery experience, pricing, and overall service. Businesses rely on this feedback to improve their offerings and maintain a competitive advantage in the market. However, analyzing large volumes of textual data manually is time-consuming and inefficient. As a result, automated methods are required to extract useful insights from customer opinions in a faster and more accurate way.

Sentiment analysis is a widely used technique that helps in identifying the emotional tone behind textual data. It is a key application of Natural Language Processing, where the main goal is to classify text into different sentiment categories such as positive, negative, or neutral. Traditional sentiment analysis methods mainly depend on simple rules or basic machine learning algorithms. These approaches work well for straightforward sentences but often fail when dealing with complex language patterns.

One of the major challenges in sentiment analysis is understanding the context of a sentence. Customers often use informal language, abbreviations, emojis, or sarcasm in their reviews. For example, a sentence may appear positive but actually convey a negative meaning depending on the context. In addition, many reviews include opinions about multiple features of a product, such as quality, price, and delivery, all in a single statement. This makes it difficult for traditional systems to accurately capture the true sentiment.

To overcome these limitations, modern techniques focus on improving both context understanding and relationship modeling within the text. Advanced language models are capable of analyzing the sequence of words and understanding their meaning in context. These models can capture subtle differences in language and provide more accurate sentiment predictions. However, they may not fully capture the relationships between different aspects mentioned in a review.

Graph-based approaches offer a useful solution to this problem by representing text as a network of connected elements. In this representation, words or phrases are treated as nodes, and their relationships are represented as connections. This allows the system to better understand how different parts of a sentence are related to each other. By analyzing these relationships, it becomes easier to identify which opinion is associated with which product feature.

The proposed approach aims to improve the accuracy and reliability of sentiment analysis systems used in online platforms. It helps businesses gain deeper insights into customer opinions, enabling better decision-making and improved customer satisfaction. By using advanced techniques, this research contributes to the development of more intelligent and efficient sentiment analysis solutions for the growing e-commerce industry.

2. The Evolution of Sentiment Analysis in Retail

The retail industry has undergone a major transformation with the growth of digital technologies and online shopping platforms. Customers today prefer to share their experiences through online reviews, ratings, and comments. These reviews play an important role in influencing other customers and also help businesses understand customer satisfaction. Because of this, analyzing customer feedback has become an essential part of modern retail systems.

In the early stages, sentiment analysis was carried out using simple rule-based methods. These methods depended on predefined lists of positive and negative words to determine the sentiment of a sentence. For example, words like "good" or "excellent" were considered positive, while words like "bad" or "poor" were considered negative. Although these methods were easy to use, they were not very accurate. They could not understand the actual meaning of a sentence, especially when the context was complex.

As the need for better analysis increased, machine learning techniques were introduced. These methods used training data to learn patterns and classify customer reviews into different sentiment categories. Models such as Naive Bayes and Support Vector Machines became popular for this purpose. These approaches improved accuracy compared to rule-based methods, but they still had limitations. They struggled with informal language, sarcasm, and sentences that contained multiple opinions.

With further advancements, deep learning models were developed to handle complex text data more effectively. These models were capable of understanding the sequence of words and capturing the context within a sentence. This made sentiment analysis more reliable and suitable for real-world applications. However, even these advanced models mainly focused on word sequences and did not fully capture the relationships between different aspects mentioned in a review.

In the retail domain, customer reviews often include opinions about multiple product features such as quality, price, and delivery. Understanding how these different aspects are

connected is important for accurate sentiment analysis. This led to the development of more advanced approaches that consider both context and relationships within text. The evolution of sentiment analysis in retail shows a clear shift from simple keyword-based methods to more intelligent and structured approaches that aim to provide deeper insights into customer behavior.

3. Identifying Gaps in Current E-Commerce Technologies

Even though e-commerce technologies have improved a lot over time, there are still several challenges in understanding customer sentiment accurately. One of the main problems is the complexity of customer reviews. Many reviews contain mixed opinions where a customer may like one feature of a product but dislike another. Traditional sentiment analysis systems often fail to separate these opinions and may classify the entire review incorrectly.

Another major issue is the use of informal language in online reviews. Customers usually write in a casual style using slang, abbreviations, or short sentences. They may also use emojis or express emotions indirectly. This type of language is difficult for existing systems to understand properly. As a result, the actual meaning of the review may not be captured correctly.

Sarcasm and indirect expressions are also important challenges. For example, a sentence may appear positive but actually express a negative feeling. Most traditional and basic machine learning models are not able to detect such cases. This leads to incorrect sentiment classification and reduces the reliability of the analysis.

Many current systems focus only on the overall sentiment of a review rather than understanding specific details. In e-commerce, it is important to know what exactly the customer likes or dislikes about a product. Without this detailed analysis, businesses may not get clear insights into customer preferences. This limits their ability to improve products and services effectively.

Another gap in existing technologies is the lack of adaptability. Customer behavior and language change over time, but many sentiment analysis models do not update themselves regularly. This makes them less effective in handling new types of expressions and trends. In addition, most systems do not combine different techniques to improve performance. They either focus on text meaning or relationships between words, but not both together.

Because of these limitations, there is a need for a more advanced approach that can handle complex language, understand context, and capture relationships within text. Addressing these gaps can lead to more accurate sentiment analysis and better decision-making in e-commerce platforms.

4. The Proposed Framework: Graph-Enhanced Transformers

To overcome the limitations of existing sentiment analysis methods, this study proposes a graph-enhanced transformer-based framework for analyzing consumer sentiment in e-commerce. The main idea of this approach is to combine the strengths of two powerful techniques: contextual understanding of text and relationship modeling between different parts of a sentence. By integrating these two aspects, the system can provide more accurate and meaningful sentiment analysis.

In this framework, customer reviews are first processed to understand their overall meaning. The transformer component plays an important role in this step. It helps the system understand the context of words in a sentence by focusing on how each word relates to others. This allows the model to capture the true meaning of a sentence, even when the language is complex or informal. It is especially useful in handling cases such as sarcasm, mixed emotions, and indirect expressions.

Along with contextual understanding, the framework also uses a graph-based approach to model relationships within the text. In this method, words or phrases in a sentence are treated as nodes, and their connections are represented as edges. This structure helps in identifying how different parts of a sentence are linked. For example, it can connect a specific opinion to a particular product feature, making it easier to understand aspect-level sentiment.

By combining these two techniques, the proposed framework is able to analyze both the meaning and structure of customer reviews. This leads to better identification of sentiments, especially in cases where a review contains multiple opinions. The system can separate different sentiments within the same review and associate them with the correct product features.

Another advantage of this framework is its ability to handle real-world data effectively. Customer reviews in e-commerce are often unstructured and written in a casual style. The proposed approach adapts well to such data and provides reliable results. It improves the overall performance of sentiment analysis systems and helps businesses gain deeper insights into customer feedback.

Overall, the graph-enhanced transformer framework offers a more advanced and efficient solution for consumer sentiment analysis. It addresses the major challenges of existing systems and provides a better way to understand customer opinions in the e-commerce domain.

5. System Architecture and Implementation

The proposed system is designed to process and analyze customer reviews in a structured and efficient way. It follows a step-by-step approach that includes data collection, preprocessing, analysis, and result generation. Each component of the system plays an important role in ensuring accurate sentiment classification and meaningful insights.

The first stage of the system is data collection. In this stage, customer reviews are gathered from various e-commerce platforms. These reviews may include feedback about product quality, delivery, pricing, and overall experience. The collected data is usually unstructured and contains different writing styles, which makes it necessary to process the data before analysis.

The next stage is data preprocessing. In this step, the raw text is cleaned and prepared for further processing. This includes removing unwanted symbols, correcting basic text issues, and converting all text into a consistent format. The text is then broken into smaller units so that the system can analyze it more effectively. This step improves the quality of the data and helps the system understand the content more clearly.

After preprocessing, the system applies the graph-enhanced transformer approach. In this stage, the text is analyzed using two important components. The first component focuses on understanding the context and meaning of the sentence. The second component identifies the relationships between different words or phrases in the text. By combining these two components, the system is able to understand both what the customer is saying and how different parts of the sentence are connected.

The processed data is then passed to the sentiment classification module. This module categorizes each review into different sentiment classes such as positive, negative, or neutral. In addition to overall sentiment, the system can also identify sentiments related to specific product features. This provides more detailed insights into customer opinions.

Finally, the results are stored and presented in a useful format. The system may generate summaries, reports, or visual representations that help businesses understand customer feedback easily. This information can be used to improve products, enhance customer satisfaction, and support decision-making.

The architecture of the system is flexible and scalable. It can handle large volumes of data and can be integrated with existing e-commerce platforms. This makes it suitable for real-world applications where continuous analysis of customer feedback is required.

6. Analysis of Performance and Practical Application

The proposed graph-enhanced transformer approach shows better performance compared to traditional sentiment analysis methods. By combining contextual understanding with relationship modeling, the system is able to analyze customer reviews more accurately. This is especially useful when dealing with complex reviews that contain multiple opinions about different product features.

One of the main strengths of the system is its ability to handle mixed sentiments. In many cases, a single review may include both positive and negative feedback. The proposed approach can separate these opinions and associate them with the correct aspects of the product. This provides more detailed and meaningful insights compared to systems that only classify overall sentiment.

The system also performs well when analyzing informal language, which is commonly used in e-commerce reviews. Customers often use simple words, abbreviations, or casual expressions while writing reviews. The proposed method can understand such variations and still identify the correct sentiment. This makes it suitable for real-world applications where data is not always structured or formal.

Another important advantage is its ability to connect sentiments with specific product features. For example, the system can identify whether a customer is satisfied with the product quality but not with the delivery service. This level of detail helps businesses understand exactly where improvements are needed.

From a practical point of view, the system can be used by e-commerce companies to monitor customer feedback on a regular basis. It can help in identifying common issues faced by customers and provide suggestions for improvement. Businesses can use this information to enhance product quality, improve services, and increase customer satisfaction.

The system can also support decision-making by providing clear insights into customer preferences and trends. It can be integrated into dashboards or reporting tools, making it easier for managers to track performance and take necessary actions. Although the system performs well, there is still scope for improvement, especially in handling highly complex language patterns and expanding its use to multiple languages.

7. Conclusion and Future Directions

This study presents a graph-enhanced transformer approach for consumer sentiment analysis in e-commerce. The proposed method focuses on improving the understanding of customer reviews by combining contextual analysis with relationship modeling. This approach helps in overcoming the limitations of traditional sentiment analysis techniques, which often fail to handle complex and unstructured data.

The system is capable of analyzing customer feedback more accurately, especially in cases where reviews contain mixed opinions or informal language. It can identify sentiments related to specific product features, providing more detailed insights for businesses. This makes the proposed approach highly useful for real-world applications in the e-commerce domain. The results indicate that combining different techniques leads to better performance in sentiment analysis. By understanding both the meaning of the text and the relationships between words, the system can provide more reliable and meaningful results. This helps businesses make better decisions and improve customer satisfaction.

In terms of future directions, the system can be further enhanced by improving its ability to handle more complex language patterns and different writing styles. It can also be extended to support multiple languages, which is important for global e-commerce platforms.

Another area for improvement is real-time sentiment analysis, where the system can process customer feedback instantly as it is generated.

Overall, this research contributes to the development of more advanced sentiment analysis systems and provides a strong foundation for future improvements. The proposed approach can play an important role in helping businesses better understand customer behavior and improve their services in a competitive digital environment.

8. References:

1. Pang, B., and Lee, L., "Opinion Mining and Sentiment Analysis," Foundations and Trends in Information Retrieval.
2. Liu, B., "Sentiment Analysis and Opinion Mining," Morgan & Claypool Publishers.
3. Devlin, J., Chang, M. W., Lee, K., and Toutanova, K., "BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding."
4. Hutto, C., and Gilbert, E., "VADER: A Rule-Based Model for Sentiment Analysis of Social Media Text."
5. Cambria, E., "Affective Computing and Sentiment Analysis," IEEE Intelligent Systems.
6. Zhang, Y., and Wallace, B., "A Sensitivity Analysis of Convolutional Neural Networks for Sentence Classification."
7. Kipf, T. N., and Welling, M., "Semi-Supervised Classification with Graph Convolutional Networks."
8. Vaswani, A., et al., "Attention Is All You Need," Advances in Neural Information Processing Systems.
9. Goldberg, Y., "A Primer on Neural Network Models for Natural Language Processing."
10. Young, T., Hazarika, D., Poria, S., and Cambria, E., "Recent Trends in Deep Learning Based Natural Language Processing."

Citation: Kanuri Raghu and Kanuri Harsha Vardhan 2026. "A Graph-Enhanced Approach for Consumer Sentiment Analysis". *International Journal of Academic Research*, 13(1): 171-176.

Copyright: ©2026 Kanuri Raghu and Kanuri Harsha Vardhan. This is an open-access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.