**Abstract**

In the modern era of digitalization, e-commerce websites produce large volumes of customer data. But most companies fail to derive meaningful insights that can lead to customer satisfaction and sales. This project aims to apply AI-based sentiment analysis to identify customer feedback and enhance e-commerce service quality. We utilize Natural Language Processing (NLP) methods, especially transformer-based models such as BERT, to process customer reviews. The goal is to categorize sentiments (positive, negative, neutral) and provide actionable feedback to e-commerce businesses. Using Python, Pandas, and Scikit-learn, we handle data, train sentiment models, and assess performance using accuracy, precision, recall, and F1-score. We discover that deep learning-based models are superior to traditional approaches, giving deeper sentiment insight. This project demonstrates how AI can help enhance business decision-making by deriving high-quality insights from customers' comments, thus leading to better service and customer retention.

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**Introduction**

E-commerce has revolutionized how people shop, with ease, variety, and affordability. With millions of transactions occurring daily, however, businesses cannot understand the needs of their customers and solve pain points. The conventional analysis of customer reviews relies on human inspection, which is time-consuming and inefficient. AI-driven sentiment analysis provides a scalable solution, enabling businesses to extract insights from millions of customer reviews in real time.

Sentiment analysis is an NLP sub-domain that identifies the text's positive, negative, or neutral sentiment. E-commerce reviews can be analyzed by companies using AI models to discover patterns in customer satisfaction, detect common complaints, and infer data-driven recommendations for business and product development. This project aims to develop a model of sentiment analysis to classify customer reviews and facilitate actionable results for user experience improvement and business outcome.

We use data from sources like Kaggle, Amazon, and Flipkart, pre-process text data, and train various machine learning models such as logistic regression, Random Forest, and deep learning-based BERT. Model performance is evaluated with classification metrics such as accuracy, precision, recall, and F1-score by the research.

Through this project, we showcase how sentiment analysis using AI is able to reinterpret customer feedback into useful business intelligence for enhancing the quality of services and customer loyalty.

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**Literature Review**

Several research studies highlight the importance of sentiment analysis in e-commerce. Predefined word-based and lexicon-based approaches such as Sentiment140 rely on predefined word lists to categorize sentiment but cannot identify context and sarcasm. More recent approaches rely on machine learning for their sentiment classification, which has profoundly improved sentiment classification accuracy.

Machine learning models such as Naïve Bayes, Support Vector Machines (SVM), and Random Forest have been widely used for sentiment classification. However, deep learning models such as Long Short-Term Memory (LSTM) networks and transformers (e.g., BERT, RoBERTa) have surpassed traditional models in extracting contextual sentiment, particularly in large datasets.

Research has shown that the application of pre-trained transformer models like BERT improves accuracy for sentiment analysis tasks by drawing on vast amounts of existing textual knowledge. Google and OpenAI research has proven that fine-tuned transformer models are superior to conventional machine learning models in NLP tasks and can be used in e-commerce.

This research is an improvement on existing literature through the application and comparison of traditional and modern sentiment analysis techniques to demonstrate the superior performance of transformer-based models in customer sentiment analysis.

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**Methodology**

**Problem Formulation**

The objective is to develop a sentiment analysis model for e-commerce reviews that classifies them as positive, negative, or neutral. The results will allow companies to detect problems in common, enhance customer experience, and increase product quality.

**Data Sources & Preprocessing**

We are using a customer review dataset from Kaggle, with product reviews assigned ratings. Our preprocessing includes:

• Special character, number, and stopwords removal.

• Word tokenizing and stemming using the NLP approaches.

• Using text data encoding with TF-IDF and Word2Vec embedding for the baseline models, since transformers use pre-trained tokenization techniques.

**Model Selection**

We compare a number of models for sentiment analysis:

1. **Classical Machine Learning** – Logistic Regression, SVM, and Random Forest.

2. **Deep Learning** – LSTM, CNN, and BERT.

3. **Evaluation Metrics** – Precision, Accuracy, Recall, and F1-score.

Training of models is done using Python's Scikit-learn, TensorFlow, and Hugging Face's Transformers library.

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**Results**

**Model Performance Comparison**

After training the models and comparing them, we have:

• SVM & Logistic Regression are quite good for small data sets but are bad when used in complex sentence structures.

• Random Forest has higher accuracy but lacks context awareness.

• LSTM learns sequential dependency, which gives better performance compared to traditional models.

• BERT is the most accurate and contextualized, hence the best model for sentiment classification.

**Sentiment Analysis Insights**

• Positive Reviews: Customers appreciate speedy delivery, quality of product, and prices.

• Negative Reviews: Complaints are usually on delayed deliveries, product defects, and poor customer service.

• Neutral Reviews: Usually contain generic comments or mixed experiences.

Through trend analysis, businesses can maximize operations, such as improving logistics for faster deliveries or addressing frequent product issues.

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**Conclusion**

This project efficiently applied AI-powered sentiment analysis to classify customer reviews, offering insights for online retailers. Our findings demonstrate the strength of deep learning models like BERT in examining customer sentiment compared to traditional methods.

The study demonstrates how AI can automatically carry out massive-scale sentiment analysis with reduced human effort while improving accuracy. Businesses can leverage this technology to enhance customer satisfaction, increase product offerings, and streamline operations.

Future work can explore applying the model to categorize multilingual reviews, such as aspect-based sentiment analysis, and leveraging sentiment data to add to recommendation systems for improved personalization of the shopping experience.