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Predicting Customer Sentiment from Bengali Food Reviews of Social Media using Deep Learning

Kakoly Islam Tanjum[1*], Tawhid Ahmed Komol[1], Sheak Rashed Haider Noori[1]

[1]Department of Computer Science Engineering, Daffodil International University, Dhaka-1341, Bangladesh

Abstract: Predicting customer sentiment from social media Bengali food reviews using a combination of traditional machine learning and deep learning algorithms. The dataset includes customer reviews labeled 'positive' or 'negative,' showing views on various food experiences. To analyze and classify the sentiment of Bengali food reviews, multiple algorithms, such as Bernoulli Naive Bayes, Support Vector Machine, Logistic Regression, K-Nearest Neighbors, Decision Tree Classifier, Long Short-Term Memory, and Convolutional Neural Networks are used. The study started by creating an overview for sentiment classification using classic machine learning algorithms such as BNB, SVM, LR, KNN, and Decision Tree. Following that, deep learning models such as LSTM and CNN are used to harness neural network power in collecting complicated patterns in text-based information. CNN outperforms all other algorithms, achieving an impressive accuracy of 97.60% in predicting customer sentiment. CNN performs better than other models because it can learn organized visualizations of features. This ability helps it identify specific context information and small differences found in Bengali food reviews.

Keywords: *social media, Bengali food reviews, customer sentiment, deep learning, natural language processing*

Introduction: Social media's introduction in recent years has had an impact on the way people communicate, express their opinions, and share their experiences. These developments have been most obvious in the area of food and food-related experiences. People from different cultures and backgrounds now use websites like Facebook, Twitter, Instagram, and specialized review platforms to share their opinions on the meals they have [1]. This large number of users' details, which includes reviews of Bangla food, is an important source for learning how people feel about various restaurants and food items. For customers and organizations, their ability to accurately evaluate customer sentiment is of the highest priority. When choosing restaurants or meals to try, it helps customers make informed decisions, providing an enjoyable eating experience. Understanding client sentiment is important for businesses such as those who work in the restaurant business since it can lead to changes in menu options, service standards, and customer satisfaction. Natural language processing (NLP) applications of deep learning techniques take on a major role in this space [2]. This study aims to apply deep learning models primarily to predict customer sentiment from Bangla food reviews. Sentiment analysis is especially known for NLP-based works that include evaluating input from text as positive or negative. The complexity of human language, which can include slang words, jokes, and ways of showing sentiments in different contexts, presents challenges for sentiment analysis [3]. Millions of people speak Bangla over the Indian subcontinent and worldwide [4], and it offers special advantages and drawbacks for sentiment studies. By addressing these challenges and using the significant language variety in Bangla, this study aims to develop Deep learning, another type of machine learning is known as a highly effective NLP method. By addressing these challenges and using the significant language variety in Bangla, this study aims to develop models that can accurately identify the sentiment in Bangla food reviews posted on social media. Deep learning, another type of machine learning, is known as a highly effective NLP method. The ability of models like Convolutional Neural Networks (CNNs) [4], Long Short-Term Memory networks (LSTMs) [4], and transformer-based designs like BERT [5] to understand and translate human language has been remarkable.

This research aims to use deep learning models to evaluate the diverse sentiments shown in Bengali food reviews and evaluate them as positive or negative. The objective of this project is to classify sentiments further. We aim to propose a custom-layered CNN architecture that can precisely predict the sentiment of customers. To summarize, this study addresses the remarkable combination of social media, customer sentiment, Bengali language, and deep learning. It aims to improve consumers' eating experiences while helping restaurants in their goal of offering outstanding service to their customers. Our goal is to use deep learning to find the challenging online platforms of emotions present in Bangla food reviews and to use this information to the benefit of anyone as well.

Statement of the Problem: Using deep learning techniques, this study aims to solve the problem of effectively predicting consumer sentiment from social media networks' Bengali food reviews. To deliver meaningful information to customers and restaurant sector firms equally, it seeks to overcome the linguistic complexity and contextual variations found in the Bangla language.

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Corresponding author details: Kakoly Islam Tanjum
E-mail address:kakoly15-3250@diu.edu.bd
Tel: +8801759495823

Methodology: The deep learning approach for predicting customer sentiment from social media reviews of Bengali food follows a structured procedure that includes several important steps and a flowchart in Figure 1.

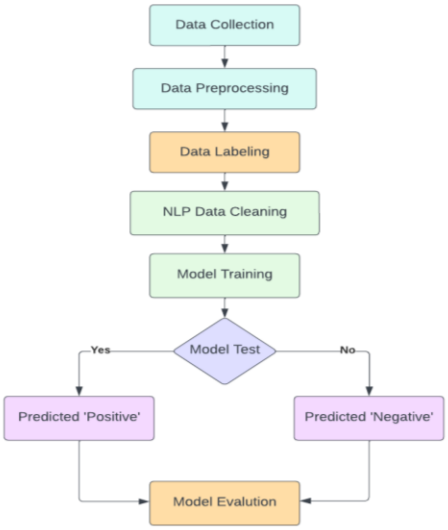

Fig 1: Overview of the proposed Methodology.

From Figure 1, we can see that the methodology of our research has 7 specific steps and they are, Data Collection, Data Preprocessing, Data Labeling, Data splitting, Models Selection, Model Training, and Model Evaluation. The steps are briefly described below:

Data Collection: Facebook and YouTube are the two primary social media platforms from which the dataset for this study was collected. A total of 2355 reviews on Bengali food were scrapped, of which 1140 were from Facebook and 1215 from YouTube. 1172 positive and 1183 negative reviews were collected from the sentiment analysis of these reviews. The split ratio was chosen at 85:15, which means that 85% of the data was used to train the models and 15% was saved for testing. The data distribution of our dataset is given in the table 1 below:

Table 1. Data distribution

Dataset Source	Target	Train Data	Test Data
YouTube	Positive	516	92
	Negative	493	87
Facebook	Positive	515	92
	Negative	513	81

This step's primary goal was to make sure that a complete and varied dataset covering a range of food experiences was collected, as this would serve as the foundation for the steps subsequently followed.

Data Preprocessing: This step involved preparing raw textual data for analysis. Because the data consisted of reviews written in Bengali, specific preprocessing processes were required, including tokenization, stop word removal, lemmatization, and text normalization. First, we need to tokenize by splitting down reviews into individual words or tokens [6] and we also eliminated frequent Bengali words that do not contribute to sentiment (such as pronouns and conjunctions) [7]. Then lemmatization is performed to reduce words to their base or root forms to unite diverse forms (e.g., "খাওয়া" to "খা") [8,9]. Our text preprocessing includes managing special characters, punctuation, and misspelled words. These techniques helped to clean the data, ensuring that the input to the models was consistent and noise-free, hence boosting model performance [10].

Data Labeling: Each review in the dataset was manually classified as 'good' or 'negative.' These labels reflect the attitude expressed in the review and serve as the foundation for training and evaluating the models. The balanced distribution of positive and negative labels (1172 positive, 1183 negative) guarantees that the models learn from a range of sentiment examples, preventing bias in predictions.

Models Selection: Several machine learning and deep learning algorithms were used to accomplish sentiment analysis. Traditional Machine Learning Models including Bernoulli Naive Bayes (BNB), Support Vector Machine (SVM), Logistic Regression (LR), K-Nearest Neighbors (KNN), and Decision Tree Classifier were used. These models are used as a benchmark for comparison to more powerful deep learning models. Long Short-Term Memory (LSTM) [11] and custom layered

Convolutional Neural Networks (CNN) [12] were chosen for their capacity to capture complex patterns in text data. CNN, in particular, was chosen because of its excellent performance in text sequence processing and contextual pattern recognition [13].
Custom Layered CNN Architecture: The proposed Custom Layered CNN Architecture [25] for Bengali food review sentiment analysis is an efficient model to address text data pattern extraction. It commences with an Embedding layer of vocab_size that maps the input words into dense 100-dimensional so that the model can be able to factor in the semantics of the words. The architecture of our custom-layered CNN is shown below in Figure 2.

The above figure 2 is of our proposed custom-layered CNN architecture for predicting Bengali food reviews where the architecture has a Conv1D layer consisting of 128 filters with a kernel size of 5 and the ReLU activation function used to impart local features from word sequences [14]. Then, to add density and to pick out the most conspicuous features, which increase computational efficiency and emphasize the most vital signals about pattern recognition [15-16], a MaxPooling1D layer is implemented. To add another level of abstraction to the feature extraction process, another Conv1D layer with 64 filters is applied [24], with the feature map being downsized with a GlobalMaxPooling1D layer which takes the maximum of the feature map across the sequence to capture the most important features from the entire sequence.

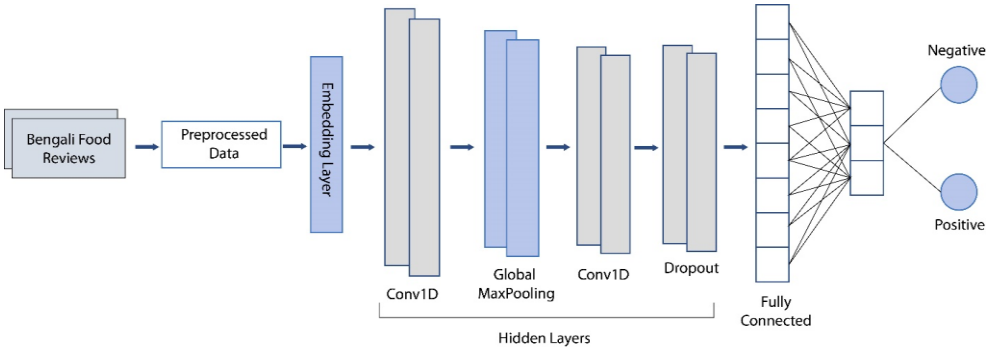

Fig. 2: Custom Layered CNN Model Architecture.

Also, in the final step, a Dense layer with 1 neuron and a sigmoid activation function estimates the probability of the sentiment to be positive or negative. This architecture with convolutional layers and pooling mechanisms in textual content, seems to address the issue of capturing local and global textual features, which in one way or another enhances on performance of sentiment classification [16].

Result and Discussion:
Model Training: The selected models were trained using the preprocessed dataset. The machine learning models utilized feature extraction techniques like TF-IDF to transform the textual data into numerical form [17]. For deep learning models like LSTM and CNN [18], word embeddings (such as Word2Vec or pre-trained embeddings) were used to convert the text into dense vectors that capture semantic meaning [19-22]. The models learned to associate specific patterns in the reviews with positive or negative sentiment. The training involved iterating over the dataset and adjusting the models' internal parameters to minimize prediction errors.

Model Evaluation: After training, the models were tested on the 15% of data set aside for evaluation. The performance of each model was evaluated using common measures such as accuracy, precision, recall, and F1-score [23]. CNN outperformed all other machine learning and deep learning models, scoring 97.60% accuracy. CNN performed better at classifying sentiment because it was able to learn hierarchical representations of the data and so capture the more complex details included in the Bengali food reviews.

Model Performance: Among the classifiers we have developed are Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), Decision Trees, KNN, Logistic Regression, Support Vector Machine, and Bernoulli Naïve Bayes (BNB) techniques. The performance was assessed using standard metrics such as accuracy, precision, recall, and F1-score. These metrics provide insights into how well each model predicts customer sentiment (positive or negative) from Bengali food reviews. The deep learning models, Long Short-Term Memory (LSTM), and custom layered Convolutional Neural Networks (CNN) outperformed traditional methods due to their ability to capture complex patterns in text data. Below in Table 2, a summary of the performance of the models is presented.

In Table 2, the performances of machine learning and deep learning models on sentiment analysis of Bengali food reviews are shown. The deep learning models were more accurate than traditional machine learning models. Our custom layered CNN emerged as the most efficient model with the highest accuracy of 97.60%; with better precision, recall, and F1-score of 0.93-0.94. LSTM also delivered good results, with 93.60% accuracy and a high value of precision. DT was chosen as the best model out of traditional models, with an accuracy of 91.68%, whereas the SVM model achieved 86.24% accuracy. The KNN was the weakest model with 71.68% accuracy while the logistic regression (LR) and Bernoulli Naïve Bayes (BNB) gave a moderate performance

of around 0.74. Thereby making CNN outperform the other models following the fact that CNN can capture patterns between the textual data, which made it the most appropriate model in the prediction of sentiments in the given context.

Table 2. Performance Evaluation all model

Model Name	Accuracy	Precision	Recall	F1-Score
BNB	82.08%	82.12%	83.19%	82.90%
SVM	86.24%	86.54%	86.34%	86.23%
LR	83.84%	83.71%	84.67%	83.72%
KNN	71.68%	73.98%	73.23%	72.63%
DT	91.68%	91.32%	92.84%	92.37%
LSTM	93.60%	97.48%	98.21%	98.53%
Proposed Model	**97.60%**	**93.34%**	**94.11%**	**93.67%**

Model Accuracy: The resulting study looks at the train and test accuracy and analyzes which algorithm performs best. To compare which performs optimally, we have used prominent machine learning and deep learning algorithms together with deep learning models. However, custom CNN gave the highest accuracy of 97.60%. The accuracy comparison of the various models is displayed in Figure 3.

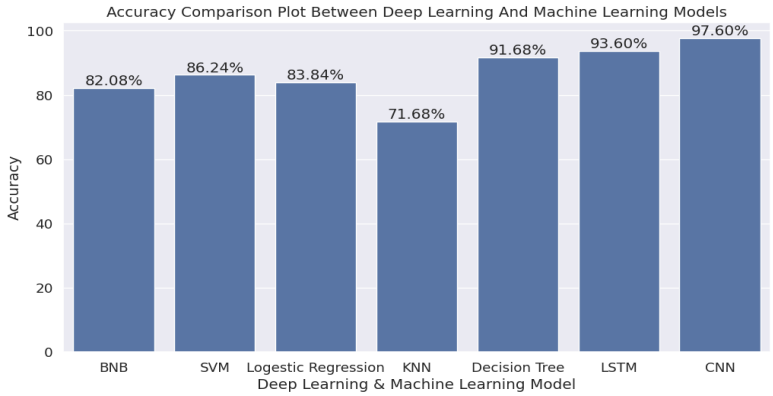

Fig. 3: Accuracy Comparison of Machine Learning and Deep Learning Models.

In Figure 3, the performance of custom CNN was quite emerging. The CNN architecture achieves the highest accuracy of 97.60%, followed by LSTM at 93.60%, both outperforming traditional models. Among machine learning models, Decision Tree (DT) performs the best with 91.68%, followed by SVM at 86.24% and Logistic Regression (LR) at 83.84%. BNB achieves 82.08%, while KNN has the lowest accuracy at 71.68%.

Deep learning models like CNN and LSTM are implemented and shown to be able to recognize complicated patterns of language in the dataset. With an accuracy of 97.60%, our custom layered CNN notably outperforms other well-known machine learning techniques such as BNB, SVM, Decision Trees, and Logistic Regression. To achieve more accurate sentiment analysis, the discussion highlights the significance of utilizing cutting-edge deep learning techniques, especially in datasets with linguistic diversity. The results advance our knowledge of the best methods for gleaning sentiment from Bangla text and offer useful information to companies looking to improve customer experiences through social media feedback in the context of Bangla food reviews.

Conclusions: Additionally, our research demonstrates the utility of custom CNN models for predicting customer sentiment from Bengali food reviews with improved accuracy. It highlights the significance of embedded words and considers Bangla-specific linguistic differences. The Custom CNN model performs better than conventional techniques in complex sentiment differentiation. Ethical factors, practical results for enterprises, and sentiment-influencing factors are also addressed. The study offers a framework for multilingual sentiment analysis, thereby creating methods for future research. In summary, this study fills

the knowledge vacuum between language-specific customer feedback and practical insights, improving customer satisfaction and providing well-informed decision-making within and outside the Bangla food industry.

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