

# Sentiment analysis from Bangladeshi food delivery startup based on user reviews using machine learning and deep learning

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## ABSTRACT

Food delivery methods are at the top of the list in today's world. People's attitudes toward food delivery systems are usually influenced by food quality and delivery time. We did a sentiment analysis of consumer comments on the Facebook pages of Food Panda, HungryNaki, Pathao Food, and Shohoz Food, and data was acquired from these four sites' remarks. In natural language processing (NLP) task, before the model was implemented, we went through a rigorous data pre-processing process that included stages like adding contractions, removing stop words, tokenizing, and more. Four supervised classification techniques are used: extreme gradient boosting (XGB), random forest classifier (RFC), decision tree classifier (DTC), and multi nominal Naive Bayes (MNB). Three deep learning (DL) models are used: convolutional neural network (CNN), long term short memory (LSTM), and recurrent neural network (RNN). The XGB model exceeds all four machine learning (ML) algorithms with an accuracy of 89.64%. LSTM has the highest accuracy rate of the three DL algorithms, with an accuracy of 91.07%. Among ML and DL models, LSTM DL takes the lead to predict the sentiment.

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## 1. INTRODUCTION

Today we live in the digital world-most of the work we have accomplished in a digital way. We use many technologies. We now use computer technology for all purposes. Its purposes increase day by day. This using of technology is increasing any country GDP [1]. We know that all countries have their own native language. All country people converse his own country native language. We communicate, comprehend, and connect with other people and nations in our language. Now a day, we try to communicate with machines in our language. It's very challenging to communicate with the device. For solving this problem, we use some techniques. This is very helpful for sharing with the machine. This technique's name is natural language processing (NLP). It is a fork of machine learning (ML). It refers to a computer's ability to interpret, modify, comprehend, and ultimately synthesize human language. NLP allows robots to communicate with one other as though they spoke the same language. We are from Bangladesh and speak Bangla as our first language. To speak with a machine or computer in our language, we must first establish a link that clarifies our language.

On the other hand, Bengalis have recently begun to use computers to teach our language. NLP is a robust technology with several advantages, yet it still has a lot of limits and issues. The use of NLP for computer recognition has received much attention [2]. However, it has received little attention. Data preparation is the most challenging part of any ML and Bengali speech presenting is difficult, it must have to solve. It takes longer to explore Bengali data. The common problem of investigation is difficulty predicting the outcome of any investigation and we must have preprocessing data.

Social media is becoming an increasingly significant aspect of everyday life in the 20<sup>th</sup> century [2]. Social networking is the first item we see when we wake up and the last item we see before heading to bed. It satisfies our daily micro-moments [3]. Nowadays, all kinds of people use social media platforms to easier their life. We quickly find anything using this social media. Facebook, YouTube, Twitter, and so many platforms are available worldwide. Its uses increase day by day. For this, social media speed up our modern communication [4]–[6]. In many surveys of contemporary society, we see that internet users are growing very highly and increasing social media platforms. Each year the number of internet users and social media increases [7]. Many people speak in Bangla language. Bangla is the predominant language of more than 200 million people in Bangladesh and many Indian states. Food review and food delivery system review are fascinating parts. Many online food delivery systems are increasing in our country. Bangladeshi most people give valuable reviews on social media in the Bangla language.

Large amounts of digital data, like review comments and Facebook status updates, have just been available in Bangla, allowing us to gauge the mood in the language [8]. Social networking has become a part of everyone's everyday routine. It allows for quick communication, sharing, and the interchange of ideas and opinions worldwide. Many kinds of food reviews we follow on many social media. Some consideration is favorable, and some are negative. User feedback is essential for any food seller and delivery system app. They follow user reviews, and it helps to follow the right way to increase their business. Bangla review data collecting is very challenging. We use social media to collect the Bangla review for food sentiment. People of Bangladesh like to eat. So Bangladeshi people's food sentiment [9]–[11] is usage. We quickly find his sentiment for reading their feedback.

Many papers, publications, and research projects concentrate on text classification, recognition, and categories, while others focus on specific language and context [12]–[14]. Transfer learning also applied to recognition and categories Bangla words [15]. Some of the work reviews that have been provided are included below. Below to establish a link to our work. Then Tripto and Ali [16] developed deep learning (DL)-based algorithms to recognize multilayer sentiment and emotion in phrases written in Bangla and Romanized Bangla. They made use of a dataset of remarks from different YouTube videos to examine how well our algorithms performed. To distinguish between sentiment and emotion, they used two different approaches: the first employs a long term short memory (LSTM) with an embedding layer, and the second, a convolutional neural network (CNN) with a core layer. Support vector machine (SVM) and Naive Bayes (NB) were employed as the foundational methodologies to detect three and five-label sentiment and emotion. The suggested method demonstrates 65.97% and 54.24% accuracy in three and five-label sentiment. They didn't include many elements and topic information in sentiment and emotion recognition. Research by Wahid *et al.* [17] describe a method for analyzing the sentiment of cricket comments written in Bangla. Recurrent neural network (RNN) is a DL variation used in this model. They employed LSTM to recall the recurrent characteristic and context meaning, which makes the model very fruitful and delivers a prediction result of roughly ninety five per cent. Their obtained dataset did not include the preprocessing phase of spell-checking and stemming. They also did not increase the target class to create an accurate NLP model for this problem domain. In order to categorize the overall polarity of Bangla microblog entries as either negative or positive, Chowdhury and Chowdhury [18] goal was to automatically extract users' views or opinions from user comments. They used a semi-supervised bootstrapping method to create the training corpus, doing away with the requirement for laborious hand annotation. By experimenting with various feature combinations, they used SVM and maximum entropy for classification and compared the effectiveness of these two ML techniques. They reached a sufficient accuracy of 93% using SVM with unigrams as features. They left the "neutral" class, which expresses neither positive nor negative sentiments. According to Tuhin *et al.* [19] looks at six different types of emotions: joyful, sad, tender, thrilled, furious, and afraid. They proposed two ML methods for identifying emotions in any Bangla text: the NB classification algorithm and the topical approach. Both the article level and the sentence level of scope have used the suggested approaches. A comparison of the performance of these two methods was conducted, and the topical approach outperformed the other by more than 90% at both levels of size. Tabassum *et al.* [20] used a random forest classifier (RFC) to identify sentiments and quantify total positive and negative against a document or sentence. Using Facebook and Twitter, they manually gathered various comments and perspectives. Their study collected 1,050 Bangla writings with positive and negative attitudes. They contemplated using unigrams, part of speech (POS) tagging, negation handling, and a classifier. They outperformed other systems with an accuracy of approximately 87%. They didn't include neutral sentiment and compound sentences in their experiment.

In their research, Salehin *et al.* [6] suggested automatically categorizing the absolute polarity of Facebook comments made in Bengali postings by Facebook users into five groups: positive, strong positive, negative, strong negative, and neutral. The Facebook graph application programming interface (API) was used to collect samples, which were then divided into two types of corpora. Ten independent annotators assigned a polarity label to each sample in both corpora (positive, strongly positive, negative, strong negative, or neutral). For each corpus, a comparison of three established classification techniques, namely NB, SVM, and LR, was shown in the ML method [20]. A popular RNN, LSTM, was tested in the DL approach. In the preprocessed corpus, SVM performed best for this classification test, with an accuracy of eighty six point seven per cent. The DL strategy did worse than the ML approach on the preprocessed corpus, but it performed better for the unprocessed corpus, with an accuracy of 72.86%. The study conducted by Trivedi and Singh [21] took into account the three online apps-based food delivery services Swiggy, Zoma-to, and UberEats. R-studio was used to gather customer tweets regarding all three businesses, and the sentiment analysis algorithm for the company-specific tweets was based on the lexicon. The score for various attitudes is calculated using a descriptive-analytical method. A positive, negative, and neutral sentiments score is calculated based on the corresponding positive, negative, and neutral feelings score. A negative and positive sentiment word list is created to match the words included in the tweets. The R-studio platform was utilized to do text mining and lexicon-based categorization for twitter sentiment analysis. The data show that Zomato has gotten more good comments than the other two businesses, with 26% positive feelings. With 13% negative feelings, Zomato had lower negative views than Swiggy and UberEats. The goal of Handani *et al.* [22] investigation is to ascertain the extent of sentiment analysis data supplied to Go-Jek by users of the Play Store comments column. Customer feedback is solicited in positive, negative, or neutral comments. The study displays the findings of a user satisfaction survey conducted at the end of the year, with unfavorable results resulting from various factors other than Go-Jek services. They didn't investigate other factors that could make Go-Jek customers unhappy.

We are focusing on numerous meal delivery apps in this research. Bangladesh offers a variety of meal delivery services, including Pathao Food, Shohoz Food, HungryNaki, and Food Panda. For this study, we have gathered a lot of both positive and negative data. All data is preprocessed after data collection. We employ numerous DL and ML algorithms for model feeding. The rest of the document is correct. In section 2, the method for identifying Bengali positive and negative mood is covered. In section 3, the experimental findings are illustrated and discussed. The document's section 4 undoubtedly wraps everything up.

## 2. PROPOSED METHOD

The main goal of our study is to develop a ML and DL model that can distinguish positive and negative Bengali food review sentences. We must go through numerous phases to attain our aim, including dataset collecting, data preprocessing, and model creation. In Figure 1, the functioning procedure is presented.

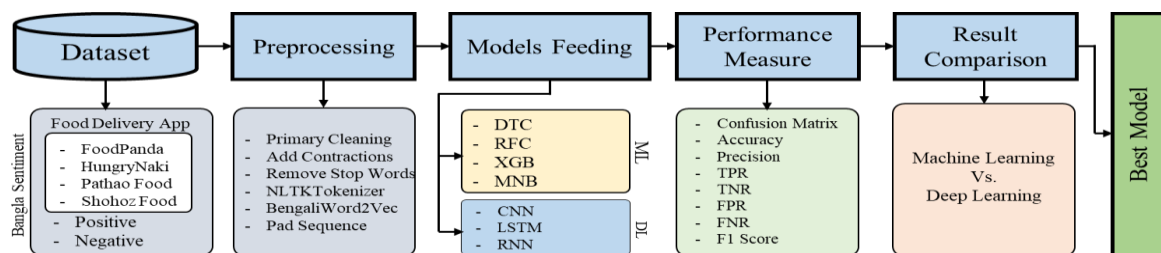


Figure 1. Working procedure diagram to predict sentiment analysis from food delivery application

### 2.1. Dataset description

Any expert ML system requires a massive amount of high-quality data to offer exceptional performance and accuracy. We gathered Bengali food reviews from several food delivery service company Facebook pages, such as Food Panda, Hungry Naki, Pathao Food, and Shohoz Food, where people expressed both positive and negative opinions. Our dataset may collect 1,400 text documents, with a total of 843 positives and 557 negative reviews, and store them in a two-column structure, with the 1<sup>st</sup> column carrying text, class, or re-mark and the 2<sup>nd</sup> column categorizing them as positive or negative. Table 1 shows the dataset distribution.

Table 1. The sample of dataset before preprocess and after processed data with class

Sentiment	Total sentiment	Unique word	Max. length	Min. length
Positive	843	1,009	47 words	13 words
Negative	557	825	26 words	6 words

## 2.2. Data preprocessing

Data preparation is most important responsibilities for any ML system, as we all know. As a result, we must go through a data filtering or processing step while using NLP. We use the procedures provided in Figure 2 into preprocess data.

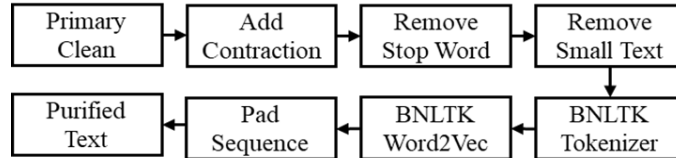


Figure 2. Step by step data pre-processing procedure to extract purified text

From Figure 2, first and foremost, we inspect our data to determine whether it is properly organized, if any text is misspelled. If there is a significant problem or error, we will personally address it. Then, to achieve the correct meaning of the line, we add some Bengali contractions. We then move on to regular expressions. Any unnecessary regular expressions, such as punctuation, numerals, special characters, and so on, are removed. We oversee Bengali stop words. The Bengali sentence has a lot of stop words in it. On the other hand, stop words make evaluating data and building models more difficult. In this case, stop terms are eliminated from our dataset using the Bangla stop word corpus. After we applied the Bangla Natural Language Processing Toolkit (BNLTK) library to tokenize and Word2Vec to compute vocab size and pad sequence. Finally, to move on to the next stage of our research investigation, we prepare or collect cleaned or purified text. Table 2 displays raw and preprocessed data.

Table 2. The sample of dataset before preprocess and after processed data with class

Raw data	Preprocessed data	Class
দেশি খাবার সবার কাছে রিপ্রেজেন্ট করা হয়েছে ,আমি ফুডপাওয়ার ওপর অনেক খুশি 🍔🍕	দেশি খাবার সবার কাছে রিপ্রেজেন্ট করা হয়েছে আমি ফুডপাওয়ার ওপর অনেক খুশি	Positive
আমি কালকে ভাউচার জিতেছি। লাইভে আমাকে এখনো ভাউচার দেওয়া হয়নি।)	আমি কালকে ভাউচার জিতেছি লাইভে আমাকে এখনো ভাউচার দেওয়া হয়নি	Negative
আমার বিকাশ একাউন্ট থেকে একাউন্ট থেকে টাকা কেটে নেওয়া হয়েছে।	আমার বিকাশ একাউন্ট থেকে একাউন্ট থেকে টাকা কেটে নেওয়া হয়েছে	Negative
ফুডপাওয়ার ডিসকাউন্ট পাওয়া যায় 🍔🍕	ফুডপাওয়ার ডিসকাউন্ট পাওয়া যায়	Positive

## 2.3. Model implementation

Our dataset was divided in half, 80:20 ratio, during the model implementation process, with eighty per cent of the data being used to train the model and the remaining twenty per cent being used for testing. We utilized four ML classification algorithms: multi nominal Naive Bayes (MNB), RFC, extreme gradient boosting (XGB), decision tree classifier (DTC), as well as three DL algorithms: CNN, LSTM, and RNN. Below is the model-relevant theory.

A very well-supervised learning model is random forest (RF) [23]. In ML, it is applicable to problems with classification and regression. It is based on ensemble approaches, which combine various classifications to simplify complicated issues and boost accuracy. Some decision trees may correctly predict the outcome while others may not since the RF uses a variety of trees to classify the information. RF are used for a variety of purposes. It dashes even with a large dataset, predicts output accurately, and requires less time for training than other techniques.

$$RFf_i = \frac{\sum_j norm f_{ij}}{\sum_{j \in \text{all features}, k \in \text{all trees}} norm f_{ijk}} \quad (1)$$

The MNB [24] is a version of the NB technique in ML that is particularly beneficial for multinomial distributed datasets. The possibility of each labeling for the input sequence is calculated using this method, which then generates the label with the highest probability as the output, making it useful when there are several classes to categorize. The following formula is used to calculate it.

$$P(A|B) = \frac{P(A) \times P(B|A)}{P(B)} \tag{2}$$

When predictor B is already available, we calculate the likelihood of class A.  $P(B)$ =B's prior probability,  $P(A)$ =denotes the class A prior probability,  $P(B|A)$ =probability of predictor B occurring given class A.

The decision tree is a member of the supervised ML methods category [25]. It could be applied to solve classification and regression-related issues. The purpose of a decision tree is to create a model that can predict the target variable by utilizing a tree representation, in which the inner node of the tree represents features and the leaf node corresponds to a class label. The formula as (3):

$$H(X) = - \sum_{i=1}^n P(x_i) \log_2 P(x_i) \tag{3}$$

XGBoost is used to create gradient-boosted decision trees. This method results in the consecutive generation of decision trees. Weights are vital in XGBoost. The decision tree, which forecasts the result, is assigned implications for each independent variable. Incorrectly indicated variables are given more weight, and the second decision tree is given these variables. To create a more accurate and reliable model, these various classifiers and predictors are combined. Regression, classification, ranking, and user-defined prediction are just a few of the problems it can resolve.

A RNN called LSTM has four gates: the forget gate (f), the input gate (I), the control gate (c), and the output gate (o). It can recognize and remember the underlying data pattern, avoiding the long-term data dependence that plagues conventional RNN algorithms. Three basic types of LSTM exist: traditional LSTM (T-LSTM), peephole LSTM (P-LSTM), and convolutional LSTM (Conv-LSTM). Our proposed LSTM model diagram model presented in Figure 3.

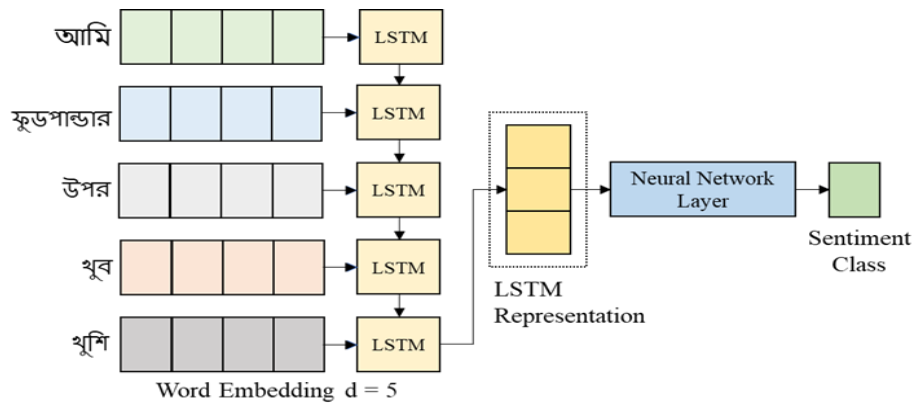


Figure 3. LSTM diagram for our proposed work

A CNN [15] is a feed-forward neural network that evaluates visual images by processing input in a grid-like layout. It's also known as a ConvNet. CNN is used to identify and categorize things in a visual. CNN has layers of neurons. Perceptron's are mathematical functions that emit an activation value after calculating the weighted sum of multiple inputs. A potential CNN model diagram is shown in Figure 4 when an image is fed into a ConvNet. An additional layer receives a set of activation functions that are produced by each tier.

In DL, RNN are a form of ANN that can analyze a set of inputs and save its state while analyzing the following sequence. RNN will assess each input before going on to the next, independent of their arrival sequence. For example, time series analysis has a sequential pattern that must be taken to comprehend. Traditional feed-forward networks can't understand this since each input is intended to be independent of the others and proposed RNN model diagram depict in Figure 5.

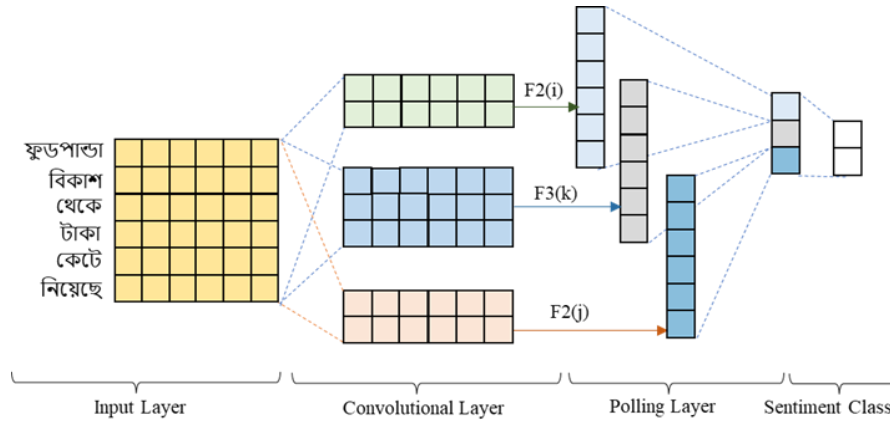


Figure 4. CNN diagram for our proposed work

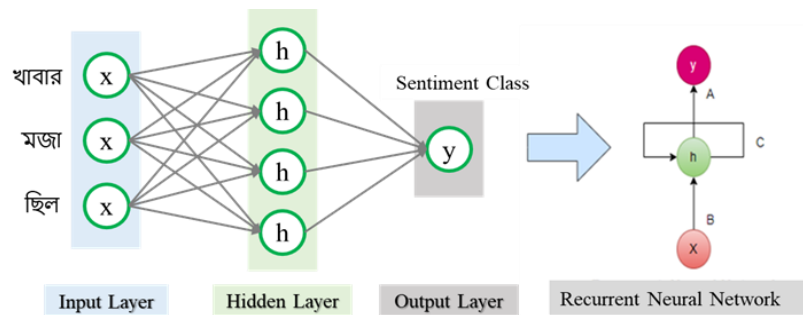


Figure 5. RNN diagram for our proposed work

## 2.4. Performance calculation

We used test data to gauge the models' performance after training. Here are some of the metrics that were calculated for performance evaluation. We discovered the most accurate model to forecast using these parameters. As (4)–(10) have been used to construct a large number of percent performance indicators based on the confusion matrix that the model provides.

$$Accuracy = \frac{True\ Positive + True\ Negative}{Total\ Number\ of\ Sentiment} \times 100\% \quad (4)$$

$$True\ Positive\ Rate\ (TPR) = \frac{True\ Positive}{True\ Positive + False\ Negative} \times 100\% \quad (5)$$

$$True\ Negative\ Rate\ (TNR) = \frac{True\ Negative}{False\ Positive + True\ Negative} \times 100\% \quad (6)$$

$$False\ Positive\ Rate\ (FPR) = \frac{False\ Positive}{False\ Positive + True\ Negative} \times 100\% \quad (7)$$

$$False\ Negative\ Rate\ (FNR) = \frac{False\ Negative}{False\ Negative + True\ Positive} \times 100\% \quad (8)$$

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive} \times 100\% \quad (9)$$

$$F1\ Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \times 100\% \quad (10)$$

## 3. RESULTS AND DISCUSSION

We used ML algorithm and a DL model to analyze sentiment from a food delivery service. DTC, RFC, XGB, and MNB are four supervised classification algorithms used. CNN, LSTM, and RNN are three

DL models utilized. The classification method can undoubtedly produce exact and accurate results depending on the class.

We set up train, test, and cross-validation for the ML algorithm to acquire correct results on our dataset. We used 50 epochs for each method and a batch size of 128 to perform DL. For DL RNN, LSTM, and rectified linear units (ReLU), sigmoid activation function for CNN, we set up the ReLU and softmax activation functions, respectively. We used Adam optimizer to calculate each parameter's learning ratio. After using the classification method, we constructed the confusion matrix for each ML and DL model. The assessment for ML and a confusion matrix represents DL classification. It places a great deal of emphasis on metering accuracy, recall, and precision. True positive rate (TPR), false negative rate (FNR), false positive rate (FPR), and true negative rate (TNR) are all reliably computed. Table 3 shows the confusion matrix produced by the models. For the two parameters in our dataset, we create a confusion matrix. There are two types of reviews: positive and negative.

Table 3. Confusion matrices for applied ML and DL algorithms

Domain	Model	TP	FN	FP	TN
ML	DTC	81	29	12	158
	RFC	91	21	13	154
	XGB	84	20	9	167
	MNB	26	59	15	180
DL	LSTM	62	17	8	193
	CNN	26	59	15	180
	RNN	57	28	36	159

Table 4 shows that the XGB model provide 89.64% accuracy to outperforms all four applied ML techniques, RF 87.81%, DTC 85.36%, and MNB 73.57% accuracy, respectively. Table 5 shows that among the three DL algorithms, LSTM has the highest accuracy rate (91.07%), RNN has a 77.14%, and CNN has a 73.57% accuracy. DL has the top place among ML and DL models, as shown in Table 6, which shows the best two models based on ML and DL domains on our Bangla sentiment data from multiple food delivery applications.

Table 4. Performance of applied ML algorithms

Model	Accuracy	TPR	FNR	FPR	TNR	Precision	F1-Score
DTC	85.36	73.64	26.36	7.06	92.94	87.10	79.80
RFC	87.81	81.25	18.75	7.78	92.22	87.50	84.26
XGB	89.64	80.77	19.23	5.11	94.89	90.33	85.28
MNB	73.57	30.59	69.41	7.69	92.31	63.41	41.27

Table 5. Performance of applied DL algorithms

Model	Accuracy	TPR	FNR	FPR	TNR	Precision	F1-Score
LSTM	91.07	78.48	21.52	3.98	96.02	88.57	83.22
CNN	73.57	30.59	69.41	7.69	92.31	63.41	41.27
RNN	77.14	67.06	32.94	18.46	81.54	61.29	64.04

Table 6. Performance of applied DL algorithms

	Model	Accuracy	TPR	FNR	FPR	TNR	Precision	F1-Score
ML	XGB	89.64	80.77	19.23	5.11	94.89	90.33	85.28
Vs DL	LSTM	91.07	78.48	21.52	3.98	96.02	88.57	83.22

The receiver operating characteristic (ROC) curve is a graph that shows how well a classification model performs at different classification levels. The ROC for our top ML model, XGB, is displayed in Figure 6 using area under the ROC curve (AUC). From Figures 7(a) and (b) depict the accuracy and loss graphs for the top LSTM DL model, respectively. Tables 7 and 8 show the results of our model's prediction of "positive" and "negative" sentiment detection. We start with the original forecast and then go on to the model's prediction. Many academics investigate on their articles based on the study of Bangla sentiment from many domains of Bangla sentences.



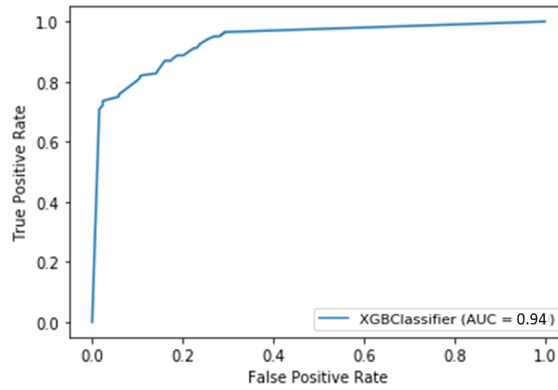


Figure 6. ROC diagram for best ML algorithms: XGB

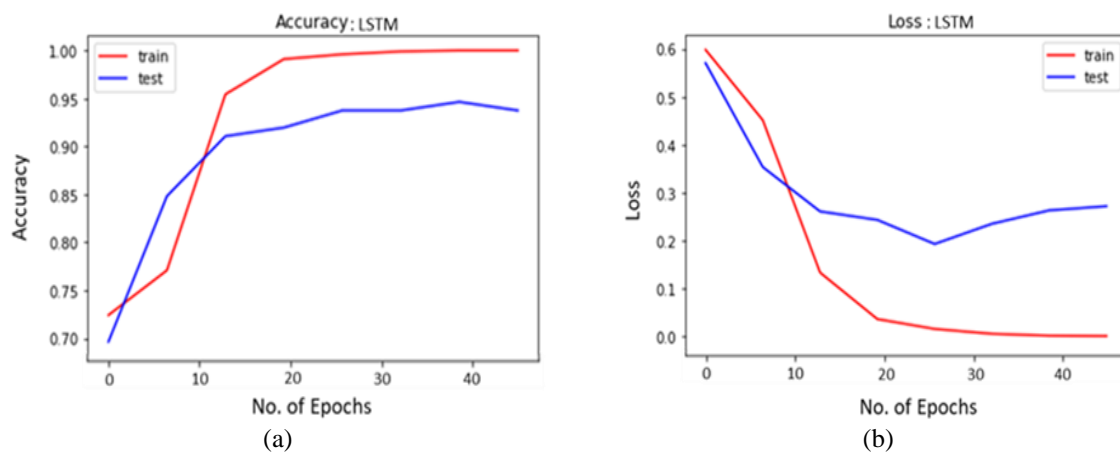


Figure 7. Diagram for (a) LSTM accuracy and (b) LSTM loss on 50 epochs

Table 7. Prediction of applied ML algorithms

Sentiment (review)	Actual class	Prediction by LSTM
আমাদের দেশীয় খাবারকে বিদেশীদের কাছে এভাবে পরিচয় করে দেওয়ার জন্য মিনিস্টার ঢাকা এবং ফুডপান্ডা কে অনেক অনেক ধন্যবাদ	Positive	Positive

Table 8. Prediction of applied DL algorithms

Sentiment (review)	Actual class	Prediction by LSTM
আমি ফুডপান্ডায় খাবার অর্ডার করছি খাবার ডেলিভারি পাইনিই রিপোর্ট করছি রিফান্ড হয়নি	Negative	Negative

#### 4. CONCLUSION

Delivery apps are the trendiest issue in the world right now. These food delivery apps are based on the internet. These sites attract an increasing number of people in business and ordinary individuals. They are making their decisions and purchasing food products through websites. Bangladesh's most popular food delivery apps include Food Panda, HungryNaki, Pathao Food, and Shohoz Food. Sen-sentiment analysis is a technique for determining the sentiment type of any given the word. By performing sentiment analysis on customer feedback, it is easy to determine the type of feedback received. Thus, this sentiment analysis will assist a meal delivery site in analyzing sentiment and determining the sentiment expressed by customers. The management will be able to improve quality of the service by knowing them. As a result, their consumer base will grow, as will their reputations. We acquired client feedback by scraping the Facebook sites of various food delivery applications. XGB, RFC, DTC, and MNB are the four super-vised classification algorithms employed. The three DL models used are CNN, LSTM, and RNN. With an accuracy of 89.64%, the XGB model outperforms all four ML techniques. Among the three DL algorithms, LSTM has the most fantastic accuracy rate, with an accuracy of 91.07%.







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