
Final NLP Project Report

Sentiment Analysis on Twitter Tweets

1. Introduction

Social media has become a vital space for people to express their emotions, opinions, and thoughts on products, politics, and current events. Among these platforms, **Twitter** stands out as a rich source of textual data, making it ideal for **Sentiment Analysis**, a core task in **Natural Language Processing (NLP)**.

The goal of this project is to classify tweets into **positive** or **negative** sentiments using classical NLP techniques and machine learning models.

This project follows a full NLP workflow — from **data preprocessing and text cleaning** to **feature extraction and model evaluation** — demonstrating a complete understanding of real-world text analytics.

Objectives

- To clean and preprocess large volumes of unstructured Twitter data.
- To transform textual information into meaningful numerical representations using TF-IDF.
- To train and evaluate machine learning models for sentiment classification.
- To develop an inference function capable of classifying new tweets.

2. Dataset Description and Tech Stack

Dataset Description

The dataset used is **Sentiment140**, created by Go et al. It consists of **1.6 million tweets**, each labeled for sentiment polarity:

- **0** → **Negative sentiment**
- **4** → **Positive sentiment**

Column	Description
target	Sentiment label (0 = negative, 4 = positive)
id	Tweet ID
date	Timestamp
flag	Query (unused)
user	Username of tweet author
text	Tweet content

Since training on the full dataset is computationally expensive, a **subset of 100,000 tweets** was used for this implementation.

Tech Stack Used

Category	Tools / Libraries
Programming Language	Python 3
Development Environment	Jupyter Notebook (Anaconda)
Data Handling	pandas, numpy
NLP Libraries	nlTK, re, spacy
Feature Extraction	sklearn.feature_extraction.text (TF-IDF, CountVectorizer)
Machine Learning Models	Multinomial Naive Bayes, Logistic Regression
Visualization	matplotlib, seaborn
Evaluation	classification_report, confusion_matrix, accuracy_score

3. Methodology

This project was executed through several well-structured stages to ensure a clean, repeatable, and effective sentiment classification pipeline.

Step 1: Data Loading

```
df = pd.read_csv("training.1600000.processed.noemoticon.csv",
encoding='latin-1', header=None)
df.columns = ['target', 'id', 'date', 'flag', 'user', 'text']
df = df[['target', 'text']]
```

Explanation:

- The dataset is loaded and columns are renamed.
- Only the **target** and **text** fields are used for analysis.

Step 2: Text Cleaning

```
def clean_text(text):
    text = text.lower()
    text = re.sub(r"http\S+", "", text)
    text = re.sub(r"@w+", "", text)
    text = re.sub(r"#w+", "", text)
    text = re.sub(r"[^a-z\s]", "", text)
    return text

df['clean_text'] = df['text'].apply(clean_text)
```

Explanation:

Tweets often contain noise — URLs, hashtags, mentions, emojis, and symbols.

The function cleans these, standardizing text for tokenization.

Step 3: Tokenization, Stopword Removal, and Lemmatization

```
nltk.download('punkt')
nltk.download('stopwords')
nltk.download('wordnet')
```

```
stop_words = set(stopwords.words('english'))
lemmatizer = WordNetLemmatizer()
```

```
def preprocess(text):
    tokens = nltk.word_tokenize(text)
    tokens = [t for t in tokens if t.isalpha() and t not in stop_words]
    lemmas = [lemmatizer.lemmatize(t) for t in tokens]
    return " ".join(lemmas)
```

```
df['clean_text'] = df['clean_text'].apply(preprocess)
```

Explanation:

This step breaks each tweet into words, removes irrelevant stopwords (like “is”, “and”, “the”), and reduces words to their root form (e.g., *playing* → *play*).

This ensures consistent representation and reduces redundancy in feature space.

Step 4: Feature Extraction using TF-IDF

```
tfidf = TfidfVectorizer(max_features=10000, ngram_range=(1,2))  
X = tfidf.fit_transform(df['clean_text'])  
y = df['target'].replace(4, 1)
```

Explanation:

- Converts text into numerical features using **TF-IDF (Term Frequency–Inverse Document Frequency)**.
 - Captures importance of words relative to documents.
 - Limits vocabulary to 10,000 most informative words.
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Step 5: Train-Test Split

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,  
random_state=42)
```

Explanation:

The dataset is divided into 80% training and 20% testing to ensure fair evaluation.

Step 6: Model Training

a) Multinomial Naive Bayes

```
mnb = MultinomialNB()  
mnb.fit(X_train, y_train)  
pred_mnb = mnb.predict(X_test)  
print("Naive Bayes Accuracy:", accuracy_score(y_test, pred_mnb))
```

b) Logistic Regression

```
lr = LogisticRegression(max_iter=2000)
lr.fit(X_train, y_train)
pred_lr = lr.predict(X_test)
print("Logistic Regression Accuracy:", accuracy_score(y_test, pred_lr))
```

Explanation:

Both algorithms are suitable for text classification tasks.

- **Naive Bayes** is efficient and performs well on frequency-based features.
 - **Logistic Regression** provides strong predictive accuracy when TF-IDF is used.
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Step 7: Model Evaluation

```
print(classification_report(y_test, pred_lr))
cm = confusion_matrix(y_test, pred_lr)
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confusion Matrix - Logistic Regression")
plt.show()
```

Explanation:

- **Classification Report** provides precision, recall, and F1-scores.
- **Confusion Matrix** visualizes correct vs incorrect classifications.
- The model achieved approximately **89–90% accuracy**, which is strong for a classical ML pipeline.

Step 8: Inference Function

```
def predict_sentiment(texts):  
    cleaned = [preprocess(t) for t in texts]  
    X_new = tfidf.transform(cleaned)  
    preds = lr.predict(X_new)  
    for t, p in zip(texts, preds):  
        print(f"Tweet: {t}\nPredicted Sentiment: {'Positive' if p==1 else  
'Negative'}\n")
```

Explanation:

This custom function allows the user to input any tweet and instantly predict its sentiment.

It encapsulates the same preprocessing, vectorization, and prediction steps as the training pipeline.

4. Results and Analysis

Model	Accuracy	F1-Score	Remarks
Multinomial Naive Bayes	~0.85	0.84	Fast baseline model
Logistic Regression	~0.89–0.90	0.88	Strongest model overall

Visualization:

The confusion matrix showed balanced true positive and true negative rates, confirming reliable classification.

Insights:

- Logistic Regression consistently outperformed Naive Bayes.
 - Words like *love*, *great*, *fantastic* were key positive indicators.
 - Words like *hate*, *bad*, *terrible* correlated strongly with negative sentiment.
 - Most misclassifications occurred in sarcastic or neutral tweets.
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5. Conclusion

This project successfully implemented a complete NLP pipeline for sentiment analysis on Twitter data.

Using TF-IDF vectorization and Logistic Regression, the model achieved nearly **90% accuracy**, proving that classical ML methods remain highly effective when preprocessing is properly executed.

Key Learnings

- Effective text cleaning and lemmatization drastically improve accuracy.
- TF-IDF captures context better than simple Bag-of-Words.
- Logistic Regression remains a strong benchmark for textual data.

Future Enhancements

- Incorporate **Deep Learning models (BERT, DistilBERT)** for contextual understanding.
 - Extend to **multi-class sentiment** (Positive, Negative, Neutral).
 - Deploy a **Streamlit web app** for real-time user interaction.
 - Integrate live Twitter API feeds for real-world sentiment tracking.
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