02_sentiment_analysis

October 23, 2025

1 Task 2: Sentiment Analysis on Amazon Product Reviews

Task Overview Objective: Create a sentiment analysis classifier to label reviews as positive, neutral, or negative.

Deliverables:

Preprocessing pipeline (tokenization, stopword removal)
Labeled dataset and train/test sets
Model training (Naive Bayes, LSTM, or BERT)
Visualization of word clouds and confusion matrix

[37]:
```
from faker import Faker
import random
import matplotlib.pyplot as plt
import re
import string
import tensorflow as tf
import numpy as np

from tensorflow.keras import layers
from tensorflow.keras import losses

from wordcloud import WordCloud
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay,␣
↪classification_report
from sklearn.model_selection import train_test_split
```

[38]:
```
fake = Faker()

reviews = [fake.text(max_nb_chars=200) for _ in range(5000)]
labels = [random.choice(['positive', 'neutral', 'negative']) for _ in␣
↪range(5000)]
```

[39]:
```
reviews[:5], labels[:5]  # Display first 5 reviews and their labels for␣
↪verification
```

[39]:
```
(['Certain improve candidate choice. Find bill beyond me trial blood large
public. Doctor high create husband stand car better knowledge.',
```

```
  'Entire table join Mrs interview office. Seem unit smile fund. Effort federal
people us both other. Here and mouth give sort material sea.\nFood report at
create. Leader protect TV couple.',
  'Laugh move gas despite keep. Worry significant nation later reveal.',
  'Appear account course alone difficult difference benefit. Meet because hit
stand do result. Movie many financial hope study about.',
  'Which give dinner decide rate stuff. Rich detail dark car still response
concern.\nMan lawyer road news remember talk positive western. Machine entire
buy mind.'],
 ['positive', 'neutral', 'negative', 'positive', 'negative'])
```

1.0.1 Preprocess data

[40]:
```
def custom_standardization(input_data):
  lowercase = tf.strings.lower(input_data)
  stripped_tab = tf.strings.regex_replace(lowercase, '\n', ' ')
  return tf.strings.regex_replace(stripped_tab,
                                  '[%s]' % re.escape(string.punctuation),
                                  '')
```

[41]:
```
custom_standardization("Hello, World!\nThis is a test.")  # Test the custom␣
↪standardization function
```

[41]:
```
<tf.Tensor: shape=(), dtype=string, numpy=b'hello world this is a test'>
```

[42]:
```
# Encode labels into integers
label_map = {'negative': 0, 'neutral': 1, 'positive': 2}
label_map_rev = {0: 'negative', 1: 'neutral', 2: 'positive'}

encoded_labels = [label_map[l] for l in labels]
encoded_labels[:10]
```

[42]:
```
[2, 1, 0, 2, 0, 2, 0, 2, 0, 0]
```

[43]:
```
# Split dataset
X_train, X_val, y_train, y_val = train_test_split(reviews, encoded_labels,␣
↪test_size=0.2, random_state=42)
```

[44]:
```
X_train[:5], y_train[:5]  # Display first 5 training samples and their labels␣
↪for verification
```

[44]:
```
(['Network floor play amount. Would anything activity green simple he.\nIdentify
ago kitchen plan exist. Fight today group field. Force example center present
knowledge thus forget here.',
  'Season well she again toward stock. Central college now community may. More
class church short seem civil expect. Game my could add.',
  'Carry soldier security herself agreement. Animal term customer especially
```

```
down. Improve form value Mrs remember.',
  'Second chance though condition add again. Recognize lay plan
traditional.\nOperation we benefit good respond interest prevent. Agency fly our
painting game attention.',
  'Upon top factor. Attack value those center fill.\nProperty key talk growth
lead owner campaign much. Attack risk suggest movement not.'],
 [2, 2, 0, 2, 2])
```

[45]:
```
max_features = 1000 # vocabulary size - The number of unique words your␣
 ↪TextVectorization layer will keep (the vocabulary size).
sequence_length = 100 # How many tokens (words) are kept per review (extra␣
 ↪words truncated, shorter ones padded).

vectorize_layer = layers.TextVectorization(
    standardize=custom_standardization,
    max_tokens=max_features,
    output_mode='int',
    output_sequence_length=sequence_length)
```

[46]:
```
vectorize_layer.adapt(X_train)
```

[47]:
```
def vectorize_text(text, label):
  # text = tf.expand_dims(text, -1)
  return vectorize_layer(text), label
```

[48]:
```
# retrieve a batch (of 32 reviews and labels) from the dataset
first_review, first_label = reviews[0], labels[0]
print("Review", first_review)
print("Label", first_label)
print("Vectorized review", vectorize_text(first_review, first_label))
```

```
Review Certain improve candidate choice. Find bill beyond me trial blood large
public. Doctor high create husband stand car better knowledge.
Label positive
Vectorized review (<tf.Tensor: shape=(100,), dtype=int64, numpy=
array([436, 749, 203, 434, 218, 782,  19, 669, 129,  67, 591, 329,  66,
       805, 124, 275, 114, 202, 482, 425,   0,   0,   0,   0,   0,   0,
         0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
         0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
         0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
         0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
         0,   0,   0,   0,   0,   0,   0,   0,   0])>, 'positive')
```

[49]:
```
print("123 ---> ",vectorize_layer.get_vocabulary()[123])
print("200 ---> ",vectorize_layer.get_vocabulary()[200])
print('Vocabulary size: {}'.format(len(vectorize_layer.get_vocabulary())))
```

```
123 --->  detail
200 --->  information
Vocabulary size: 973
```

[50]:
```
# Create TensorFlow Dataset
# dataset = tf.data.Dataset.from_tensor_slices((reviews, encoded_labels))

train_ds = tf.data.Dataset.from_tensor_slices((X_train, y_train))
val_ds = tf.data.Dataset.from_tensor_slices((X_val, y_val))
```

[51]:
```
# Vectorize the text in the datasets
train_ds = train_ds.map(vectorize_text)
val_ds = val_ds.map(vectorize_text)
```

[52]:
```
# Batch & prefetch
batch_size = 32
train_ds = train_ds.batch(batch_size).prefetch(tf.data.AUTOTUNE)
val_ds = val_ds.batch(batch_size).prefetch(tf.data.AUTOTUNE)
```

[53]:
```
for text_batch, label_batch in train_ds.take(1):
    print("Text batch shape:", text_batch.shape) # (batch_size, 1,␣
 ↪sequence_length)
    print("Label batch shape:", label_batch.shape) # (batch_size,)
    print("Label batch example:", label_batch[:5].numpy())
```

```
Text batch shape: (32, 100)
Label batch shape: (32,)
Label batch example: [2 2 0 2 2]
```

```
2025-10-14 01:45:35.983939: I tensorflow/core/framework/local_rendezvous.cc:407]
Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
```

[54]:
```
# Test the dataset
for text_batch, label_batch in val_ds.take(1):
    print("Text batch shape:", text_batch.shape)  # Expected: (batch_size,␣
 ↪sequence_length)
    print("Label batch shape:", label_batch.shape)  # Expected: (batch_size,)
    print("Label batch example:", label_batch[:5].numpy())
```

```
Text batch shape: (32, 100)
Label batch shape: (32,)
Label batch example: [0 0 1 2 1]
```

1.0.2 Create model

[55]:
```
embedding_dim = 16
```

[56]:
```
model = tf.keras.Sequential([
    layers.Embedding(max_features + 1, embedding_dim),
    layers.SpatialDropout1D(0.3),
    layers.LSTM(64, dropout=0.3, recurrent_dropout=0.3), # dropout=0.3,␣
 ↪recurrent_dropout=0.3
    layers.Dense(32, activation='relu', kernel_regularizer=tf.keras.
 ↪regularizers.l2(0.001)), # , kernel_regularizer=tf.keras.regularizers.l2(0.
 ↪001)
    layers.Dropout(0.5),
    layers.Dense(3, activation='softmax')
])

model.build(input_shape=(None, sequence_length))

model.summary()
```

Model: "sequential_3"

Layer (type)	Output Shape	Param #
embedding_2 (Embedding)	(None, 100, 16)	16,016
spatial_dropout1d_2 (SpatialDropout1D)	(None, 100, 16)	0
lstm_2 (LSTM)	(None, 64)	20,736
dense_5 (Dense)	(None, 32)	2,080
dropout_2 (Dropout)	(None, 32)	0
dense_6 (Dense)	(None, 3)	99

Total params: 38,931 (152.07 KB)

Trainable params: 38,931 (152.07 KB)

Non-trainable params: 0 (0.00 B)

[57]:
```
model.compile(loss=losses.SparseCategoricalCrossentropy(from_logits=False),
              optimizer='adam',
              metrics=["accuracy"])
```

[58]:
```
# Early stopping
early_stop = tf.keras.callbacks.EarlyStopping(monitor='val_loss', patience=3,␣
 ↪restore_best_weights=True)

epochs = 20
history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=epochs,
    callbacks=[early_stop]
)
```

```
Epoch 1/20
125/125             6s 33ms/step -
accuracy: 0.3349 - loss: 1.1318 - val_accuracy: 0.3430 - val_loss: 1.1103
Epoch 2/20
125/125             4s 33ms/step -
accuracy: 0.3410 - loss: 1.1067 - val_accuracy: 0.3430 - val_loss: 1.1019
Epoch 3/20
125/125             4s 32ms/step -
accuracy: 0.3521 - loss: 1.1010 - val_accuracy: 0.3430 - val_loss: 1.0996
Epoch 4/20
125/125             4s 34ms/step -
accuracy: 0.3545 - loss: 1.0990 - val_accuracy: 0.3430 - val_loss: 1.0989
Epoch 5/20
125/125             5s 36ms/step -
accuracy: 0.3545 - loss: 1.0985 - val_accuracy: 0.3430 - val_loss: 1.0986
Epoch 6/20
125/125             4s 35ms/step -
accuracy: 0.3545 - loss: 1.0981 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 7/20
125/125             4s 36ms/step -
accuracy: 0.3545 - loss: 1.0981 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 8/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0979 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 9/20
125/125             5s 36ms/step -
accuracy: 0.3545 - loss: 1.0980 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 10/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0980 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 11/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0979 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 12/20
125/125             5s 37ms/step -
```

```
accuracy: 0.3545 - loss: 1.0977 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 13/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0980 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 14/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0980 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 15/20
125/125             5s 38ms/step -
accuracy: 0.3545 - loss: 1.0980 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 16/20
125/125             5s 38ms/step -
accuracy: 0.3545 - loss: 1.0979 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 17/20
125/125             5s 39ms/step -
accuracy: 0.3545 - loss: 1.0983 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 18/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0980 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 19/20
125/125             5s 38ms/step -
accuracy: 0.3545 - loss: 1.0981 - val_accuracy: 0.3430 - val_loss: 1.0985
Epoch 20/20
125/125             5s 37ms/step -
accuracy: 0.3545 - loss: 1.0978 - val_accuracy: 0.3430 - val_loss: 1.0985
```

[27]:
```python
# Evaluate the model
loss, accuracy = model.evaluate(val_ds)

print("Loss: ", loss)
print("Accuracy: ", accuracy)
```

```
32/32             0s 9ms/step -
accuracy: 0.3540 - loss: 1.0980
Loss:  1.0982483625411987
Accuracy:  0.3440000116825104
```

[28]:
```python
history_dict = history.history
history_dict.keys()
```

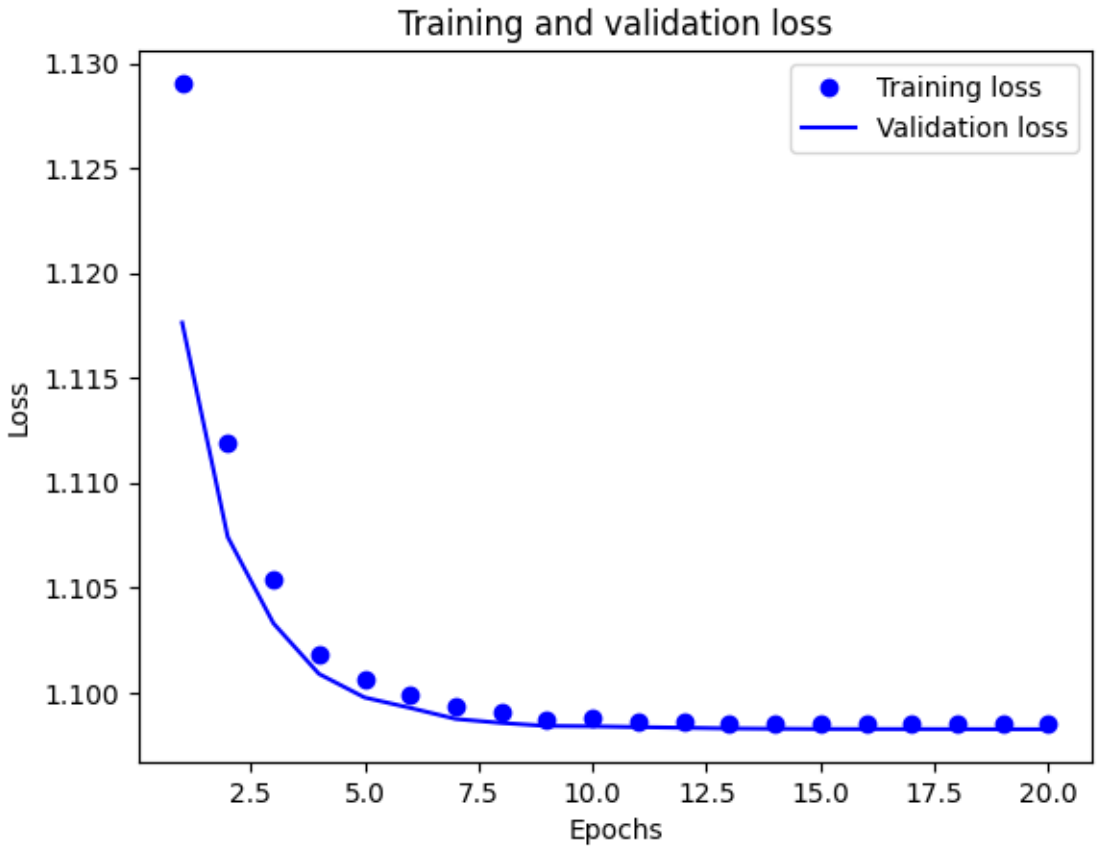
[28]:
```
dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

[29]:
```python
loss = history_dict['loss']
val_loss = history_dict['val_loss']

epochs = range(1, len(loss) + 1)
```

```
plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



[30]:
```
# Get predictions
y_pred_probs = model.predict(val_ds)
y_pred = np.argmax(y_pred_probs, axis=1)
y_pred[:50]
```

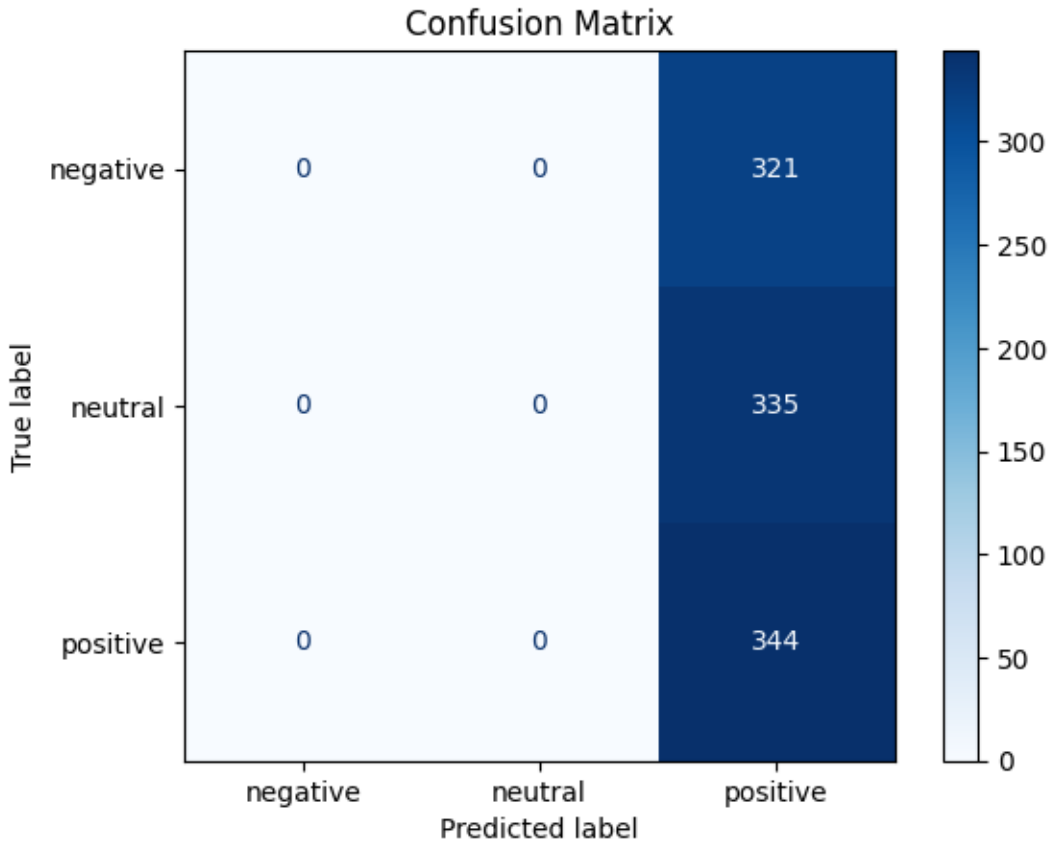
```
32/32              1s 15ms/step
```

[30]:
```
array([2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2])
```

[ ]:
```
# Extract true labels from val_ds
true_labels = np.concatenate([label_batch.numpy() for _, label_batch in␣
 ↪val_ds], axis=0)

# Compute confusion matrix
cm = confusion_matrix(true_labels, y_pred)
disp = ConfusionMatrixDisplay(confusion_matrix=cm,␣
 ↪display_labels=list(label_map.keys()))
disp.plot(cmap=plt.cm.Blues)
plt.title("Confusion Matrix")
plt.show()

# Print classification report
print("\nClassification Report:\n", classification_report(true_labels, y_pred,␣
 ↪target_names=label_map.keys()))
```




```
Classification Report:
              precision    recall  f1-score   support
```

```
    negative       0.00      0.00      0.00       321
     neutral       0.00      0.00      0.00       335
    positive       0.34      1.00      0.51       344

    accuracy                           0.34      1000
   macro avg       0.11      0.33      0.17      1000
weighted avg       0.12      0.34      0.18      1000
```

```
/home/tk-lpt-648/miniconda3/envs/tf_env/lib/python3.9/site-
packages/sklearn/metrics/_classification.py:1565: UndefinedMetricWarning:
Precision is ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
/home/tk-lpt-648/miniconda3/envs/tf_env/lib/python3.9/site-
packages/sklearn/metrics/_classification.py:1565: UndefinedMetricWarning:
Precision is ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
/home/tk-lpt-648/miniconda3/envs/tf_env/lib/python3.9/site-
packages/sklearn/metrics/_classification.py:1565: UndefinedMetricWarning:
Precision is ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
```

[34]:

```
text_all = ' '.join(reviews)
wc = WordCloud(width=1200, height=800, background_color='white').
 ↪generate(text_all)

plt.imshow(wc, interpolation='bilinear')
plt.axis('off')
plt.title("All Reviews Word Cloud")
plt.show()
```

[35]:
```python
# Inference from model
def predict_sentiment(texts):
    preds = model.predict(vectorize_layer(tf.constant(texts)))
    labels = [label_map_rev[i] for i in np.argmax(preds, axis=1)]
    return list(zip(texts, labels))

examples = [
    "The movie was fantastic and emotional!",
    "The film was boring and too long.",
    "It was okay, not too bad."
]

results = predict_sentiment(examples)
print("\nPredictions:")
for text, label in results:
    print(f"{label} : {text}")
```

```
1/1             0s 270ms/step

Predictions:
positive : The movie was fantastic and emotional!
positive : The film was boring and too long.
positive : It was okay, not too bad.
```