Text Classification - Genre Prediction

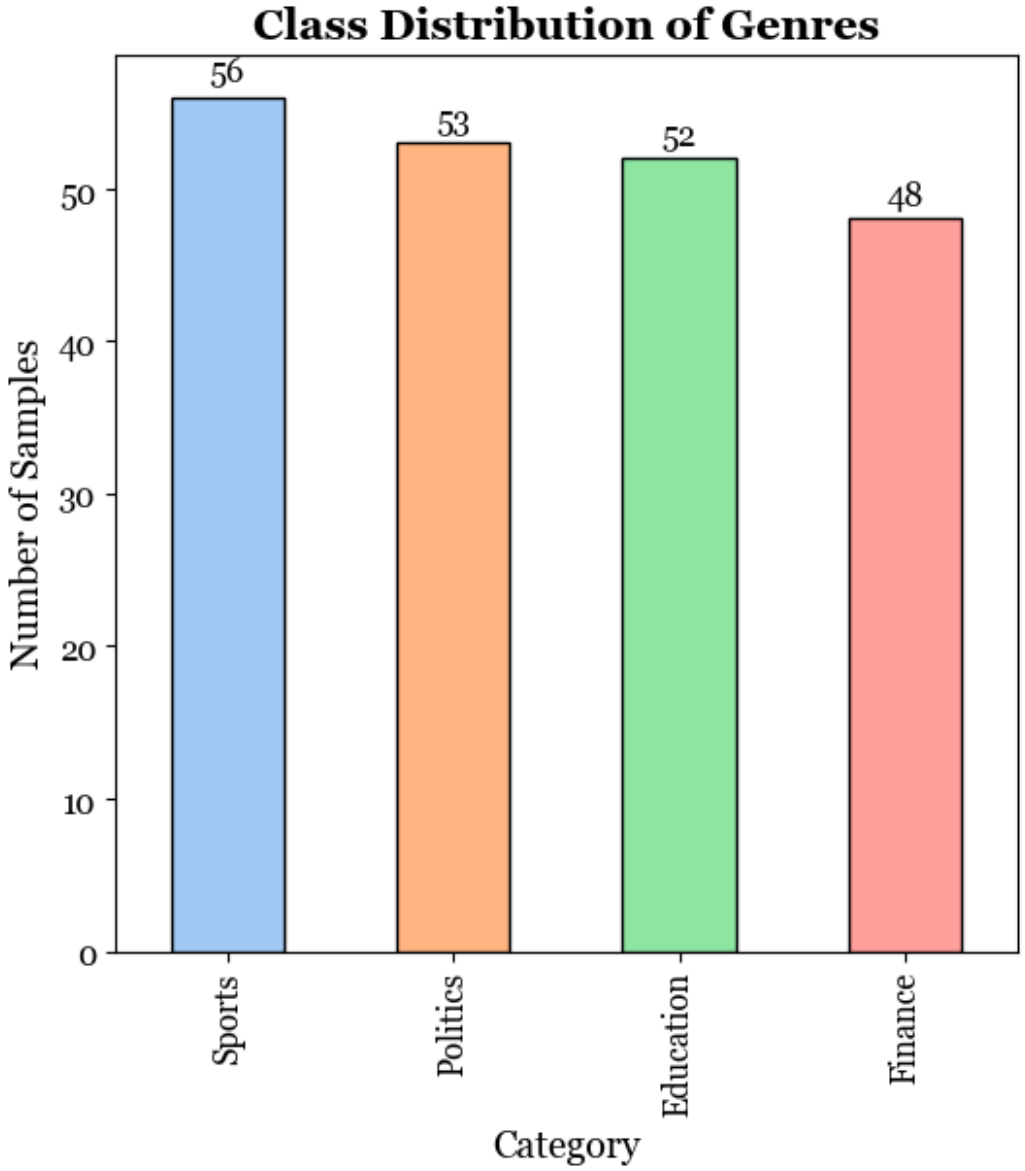
Reading Data

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

df1 = pd.read_csv('Education.csv')
df2 = pd.read_csv('Finance.csv')
df3 = pd.read_csv('Politics.csv')
df4 = pd.read_csv('Sports.csv')

df1['Category'] = 'Education'
df2['Category'] = 'Finance'
df3['Category'] = 'Politics'
df4['Category'] = 'Sports'

#print shapes of dataframes
print("Shape of Education dataframe: ", df1.shape)
print("Shape of Finance dataframe: ", df2.shape)
print("Shape of Politics dataframe: ", df3.shape)
print("Shape of Sports dataframe: ", df4.shape)
```

```
Shape of Education dataframe:  (52, 3)
Shape of Finance dataframe:  (48, 3)
Shape of Politics dataframe:  (53, 3)
Shape of Sports dataframe:  (56, 3)
```

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

df = pd.concat([df1, df2, df3, df4], ignore_index=True)

colors = sns.color_palette("pastel", df['Category'].nunique())
plt.figure(figsize=(6, 6))

ax = df['Category'].value_counts().plot(
    kind='bar',
    color=colors,
    edgecolor='black',
    linewidth=1.0
)

plt.title('Class Distribution of Genres', fontname='Georgia',
fontsize=16, fontweight='bold')
plt.xlabel('Category', fontname='Georgia', fontsize=14)
```

```
plt.ylabel('Number of Samples', fontname='Georgia', fontsize=14)
#show values above the bars
for i in ax.patches:
    ax.text(i.get_x() + i.get_width()/2, i.get_height() + 0.5,
str(i.get_height()), ha='center', va='bottom', fontname='Georgia',
fontsize=12)
#x axis values and y axis values with font georgia and fontsize 12
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)

plt.show()
```



Pre-Processing Data

```
#Make all the dataframes have the same number of rows which is the
minimum of all the dataframes
min_rows = min(df1.shape[0], df2.shape[0], df3.shape[0], df4.shape[0])
df1 = df1.sample(n=min_rows)
df2 = df2.sample(n=min_rows)
df3 = df3.sample(n=min_rows)
df4 = df4.sample(n=min_rows)

#print the shape
print("Shape of Education dataframe: ", df1.shape)
print("Shape of Finance dataframe: ", df2.shape)
print("Shape of Politics dataframe: ", df3.shape)
print("Shape of Sports dataframe: ", df4.shape)

#Concatenate all the dataframes
df = pd.concat([df1, df2, df3, df4])
df.head()
```

```
Shape of Education dataframe:  (48, 3)
Shape of Finance dataframe:  (48, 3)
Shape of Politics dataframe:  (48, 3)
Shape of Sports dataframe:  (48, 3)
```

```
                                                 Text     Label
Category
8   Charter schools offer alternatives to traditio...  positive
Education
1   Critics argue that recent improvements in the ...  negative
Education
47  Educational policies should be responsive to t...  negative
Education
15  Standardized curricula limit teachers' creativ...  negative
Education
17  Privatization efforts in education prioritize ...  negative
Education
```

```
df.shape
```

```
(192, 3)
```

```
#now shuffle the data
df = df.sample(frac=1).reset_index(drop=True)
df.shape
df.head()
```

```
                                               Text     Label
Category
0  Sportsmanship and fair play are essential valu...  positive
Sports
```

```
1  Public education should be funded adequately t...  negative
Education
2  Educational technology can be isolating and im...  negative
Education
3  Educators should receive more support and reco...  positive
Education
4  Financial regulations aim to strike a balance ...  positive
Finance
```

```
#save the dataframe to a csv file
df.to_csv('final_project_data_FINAL.csv', index=False)
```

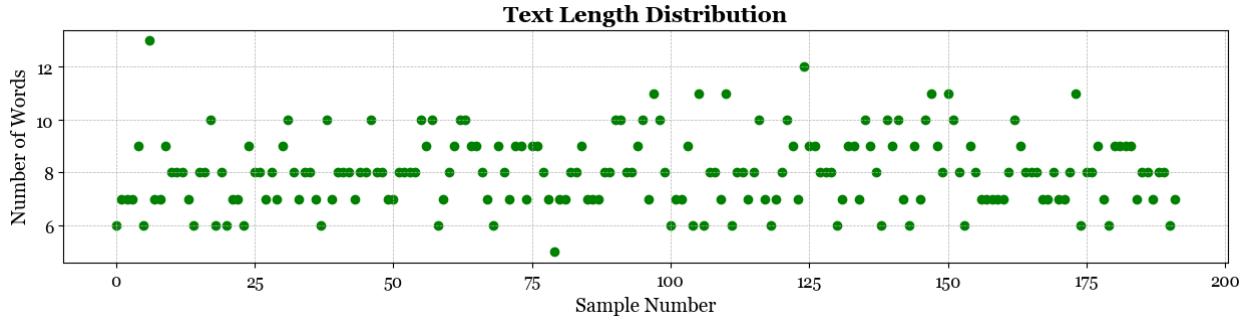
```
#for the text extract bag of words and for each sample append in the
dataframe 'df'
import re
import nltk
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from nltk.stem import PorterStemmer


from sklearn.model_selection import train_test_split

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

def preprocess_text(text):
    text = re.sub(r'[^\w\s]', '', text, re.UNICODE)
    text = text.lower()
    text = [word for word in text.split() if word not in
stopwords.words('english')]
    text = ' '.join(text)
    return text

df['Text_Preprocessed'] = df['Text'].apply(preprocess_text)
df.head()
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\itzch\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package punkt to
[nltk_data]     C:\Users\itzch\AppData\Roaming\nltk_data...
[nltk_data]   Package punkt is already up-to-date!
```

```
                                                Text     Label
Category  \
0  Sportsmanship and fair play are essential valu...  positive
Sports
1  Public education should be funded adequately t...  negative
Education
2  Educational technology can be isolating and im...  negative
```

```
Education
3  Educators should receive more support and reco...  positive
Education
4  Financial regulations aim to strike a balance ...  positive
Finance

                                    Text_Preprocessed
0  sportsmanship fair play essential values athle...
1  public education funded adequately ensure equi...
2  educational technology isolating impersonal hi...
3  educators receive support recognition crucial ...
4  financial regulations aim strike balance marke...
```

```
# calculate length of eac text in terms of words and plot as scatter
plot
df['Text_Length'] = df['Text_Preprocessed'].apply(lambda x:
len(word_tokenize(x)))
df.head()

plt.figure(figsize=(15, 3))
plt.scatter(df.index, df['Text_Length'], color='green')
plt.title('Text Length Distribution', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Sample Number', fontname='Georgia', fontsize=14)
plt.ylabel('Number of Words', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.grid(visible=True, linestyle='--', linewidth=0.5)
plt.show()
```



Feature Extraction

1. Bag of Words

```
from sklearn.feature_extraction.text import CountVectorizer
```

```
vectorizer = CountVectorizer()
X_BOW = vectorizer.fit_transform(df['Text_Preprocessed'])
X_BOW = X_BOW.toarray()
X_BOW.shape
```

```
(192, 763)
```

1. TF-IDF

```
#TF-IDF Vectorizer
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer = TfidfVectorizer()
X_TFIDF = vectorizer.fit_transform(df['Text_Preprocessed'])
X_TFIDF = X_TFIDF.toarray()
X_TFIDF.shape
```

```
(192, 763)
```

1. Bert Embeddings

```
#extract bert embeddings
import torch
from transformers import BertTokenizer, BertModel

tokenizer = BertTokenizer.from_pretrained('bert-base-uncased')
model = BertModel.from_pretrained('bert-base-uncased')

def extract_bert_embeddings(text):
    inputs = tokenizer(text, return_tensors='pt')
    outputs = model(**inputs)
    embeddings = outputs.last_hidden_state
    embeddings = torch.mean(embeddings, dim=1)
    embeddings = torch.flatten(embeddings).detach().numpy()
    return embeddings

X_BERT = df['Text_Preprocessed'].apply(extract_bert_embeddings)
X_BERT = np.array(X_BERT.tolist())
X_BERT.shape
```

```
(192, 768)
```

Train Test Split - 70:30 for each feautres

```
from sklearn.model_selection import train_test_split
X_train_BERT,X_test_BERT, y_train_BERT, y_test_BERT =
train_test_split(X_BERT, df['Category'], test_size=0.3,
```

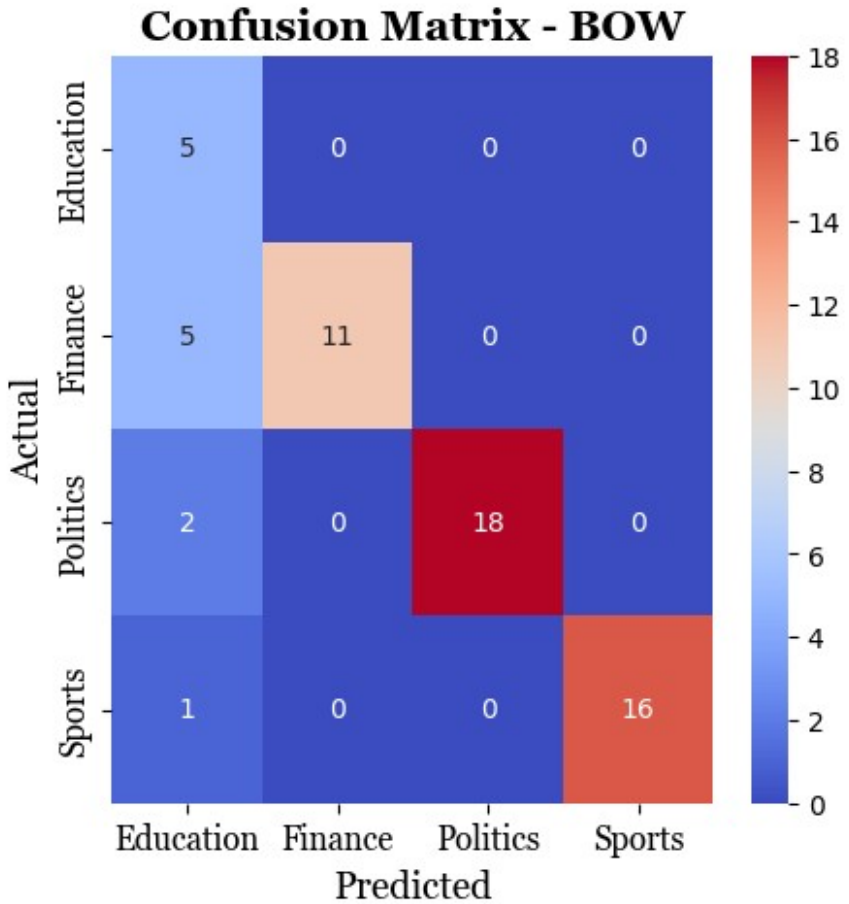
```
random_state=42)

from sklearn.model_selection import train_test_split
X_train_BOW, X_test_BOW, y_train_BOW, y_test_BOW =
train_test_split(X_BOW, df['Category'], test_size=0.3,
random_state=42)

from sklearn.model_selection import train_test_split
X_train_TFIDF, X_test_TFIDF, y_train_TFIDF, y_test_TFIDF =
train_test_split(X_TFIDF, df['Category'], test_size=0.3,
random_state=42)

#save the data to a file
import pickle

with open('train_test_data.pkl', 'wb') as f:
    pickle.dump([X_train_BERT, X_test_BERT, y_train_BERT, y_test_BERT,
X_train_BOW, X_test_BOW, y_train_BOW, y_test_BOW, X_train_TFIDF,
X_test_TFIDF, y_train_TFIDF, y_test_TFIDF], f)
print("Data Saved Successfully")

#normalize the bOW and TFIDF data

from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()
X_train_BOW = scaler.fit_transform(X_train_BOW)
X_test_BOW = scaler.transform(X_test_BOW)

scaler2 = StandardScaler()
X_train_TFIDF = scaler2.fit_transform(X_train_TFIDF)
X_test_TFIDF = scaler2.transform(X_test_TFIDF)

#encode the target variable
from sklearn.preprocessing import LabelEncoder

encoder = LabelEncoder()
y_train_BERT = encoder.fit_transform(y_train_BERT)
y_test_BERT = encoder.transform(y_test_BERT)

encoder = LabelEncoder()
y_train_BOW = encoder.fit_transform(y_train_BOW)
y_test_BOW = encoder.transform(y_test_BOW)

encoder = LabelEncoder()
y_train_TFIDF = encoder.fit_transform(y_train_TFIDF)
y_test_TFIDF = encoder.transform(y_test_TFIDF)
```

Classifier - Gradient Booster

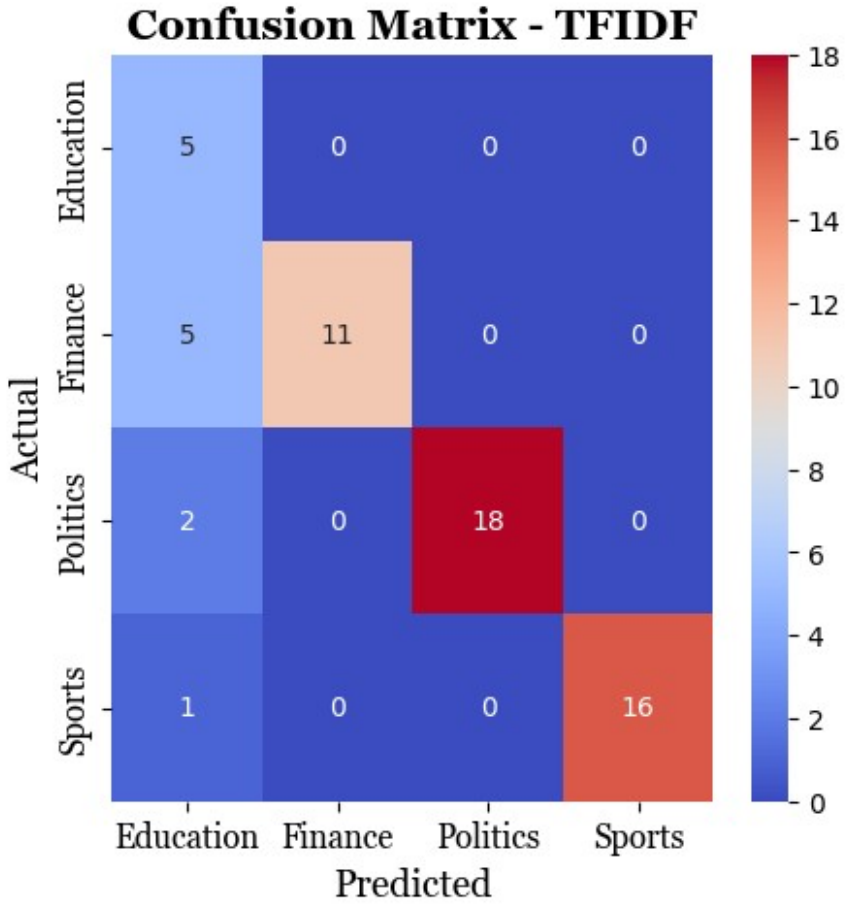
```
# Classifier - Gradient Boosting
from sklearn.ensemble import GradientBoostingClassifier

gb1 = GradientBoostingClassifier(n_estimators=100, learning_rate=1.0,
max_depth=1, random_state=0)
gb1.fit(X_train_BOW, y_train_BOW)

gb2 = GradientBoostingClassifier(n_estimators=100, learning_rate=1.0,
max_depth=1, random_state=0)
gb2.fit(X_train_TFIDF, y_train_TFIDF)

gb3 = GradientBoostingClassifier(n_estimators=100, learning_rate=1.0,
max_depth=1, random_state=0)
gb3.fit(X_train_BERT, y_train_BERT)


#Evaluation - accuracy, f1 score, confusion matrix, classification
report
from sklearn.metrics import accuracy_score, f1_score,
confusion_matrix, classification_report

#BOW-----------------------------------------------------------------
-----------------------------------------------
y_pred_BOW = gb1.predict(X_test_BOW)
accuracy_BOW = accuracy_score(y_test_BOW, y_pred_BOW)
f1_BOW = f1_score(y_test_BOW, y_pred_BOW, average='weighted')
conf_matrix_BOW = confusion_matrix(y_test_BOW, y_pred_BOW)
class_report_BOW = classification_report(y_test_BOW, y_pred_BOW)

#Confusion Matrix as heatmap wth seaborn and annot=True
import seaborn as sns
plt.figure(figsize=(5,5))
sns.heatmap(conf_matrix_BOW, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - BOW', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

#display scores
print("Accuracy - BOW: ", accuracy_BOW)
print("F1 Score - BOW: ", f1_BOW)
print("Classification Report - BOW: \n", class_report_BOW)

#TFIDF---------------------------------------------------------------
---------------------------
```

```
y_pred_TFIDF = gb2.predict(X_test_TFIDF)
accuracy_TFIDF = accuracy_score(y_test_TFIDF, y_pred_TFIDF)
f1_TFIDF = f1_score(y_test_TFIDF, y_pred_TFIDF, average='weighted')
conf_matrix_TFIDF = confusion_matrix(y_test_TFIDF, y_pred_TFIDF)
class_report_TFIDF = classification_report(y_test_TFIDF, y_pred_TFIDF)

#Confusion Matrix as heatmap wth seaborn and annot=True
import seaborn as sns
plt.figure(figsize=(5,5))
sns.heatmap(conf_matrix_TFIDF, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - TFIDF', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

#display scores
print("Accuracy - TFIDF: ", accuracy_TFIDF)
print("F1 Score - TFIDF: ", f1_TFIDF)
print("Classification Report - TFIDF: \n", class_report_TFIDF)


#BERT-----------------------------------------------------------------
----------------------------------------------------------
y_pred_BERT = gb3.predict(X_test_BERT)
accuracy_BERT = accuracy_score(y_test_BERT, y_pred_BERT)
f1_BERT = f1_score(y_test_BERT, y_pred_BERT, average='weighted')
conf_matrix_BERT = confusion_matrix(y_test_BERT, y_pred_BERT)

class_report_BERT = classification_report(y_test_BERT, y_pred_BERT)

#Confusion Matrix as heatmap wth seaborn and annot=True
import seaborn as sns
plt.figure(figsize=(5,5))
sns.heatmap(conf_matrix_BERT, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - BERT', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

#display scores
print("Accuracy - BERT: ", accuracy_BERT)
print("F1 Score - BERT: ", f1_BERT)
```

```
print("Classification Report - BERT: \n", class_report_BERT)

#Display the scores in a table and the best feature extraction
technique
import pandas as pd

data = {
    'Feature Extraction Technique': ['BOW', 'TFIDF', 'BERT'],
    'Accuracy': [accuracy_BOW, accuracy_TFIDF, accuracy_BERT],
    'F1 Score': [f1_BOW, f1_TFIDF, f1_BERT]
}

df_scores = pd.DataFrame(data)
df_scores

#best model with feature extraciton technique
best_model = df_scores.loc[df_scores['F1 Score'].idxmax()]
best_model

df_scores.head()
```

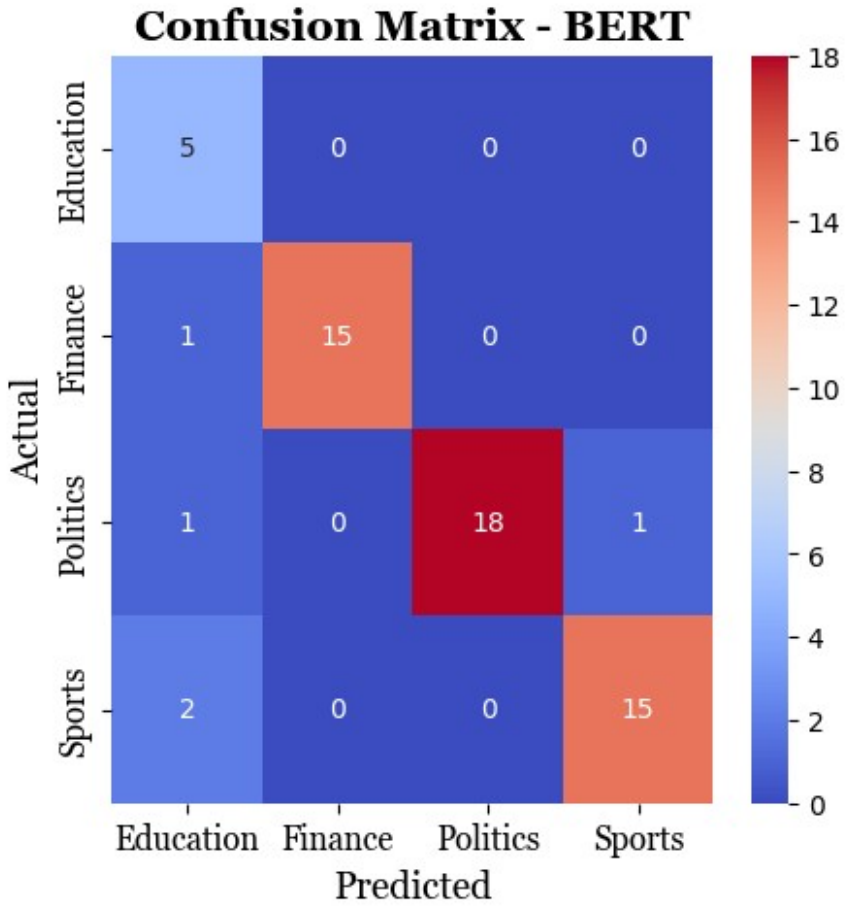


```
Accuracy - BOW:  0.8620689655172413
F1 Score - BOW:  0.8835695124261366
Classification Report - BOW:
              precision    recall  f1-score   support

           0       0.38      1.00      0.56         5
           1       1.00      0.69      0.81        16
           2       1.00      0.90      0.95        20
           3       1.00      0.94      0.97        17

    accuracy                           0.86        58
   macro avg       0.85      0.88      0.82        58
weighted avg       0.95      0.86      0.88        58
```




```
Accuracy - TFIDF:  0.8620689655172413
F1 Score - TFIDF:  0.8835695124261366
Classification Report - TFIDF:
              precision    recall  f1-score   support

           0       0.38      1.00      0.56         5
```

```
              1       1.00      0.69      0.81        16
              2       1.00      0.90      0.95        20
              3       1.00      0.94      0.97        17

       accuracy                           0.86        58
      macro avg       0.85      0.88      0.82        58
   weighted avg       0.95      0.86      0.88        58
```



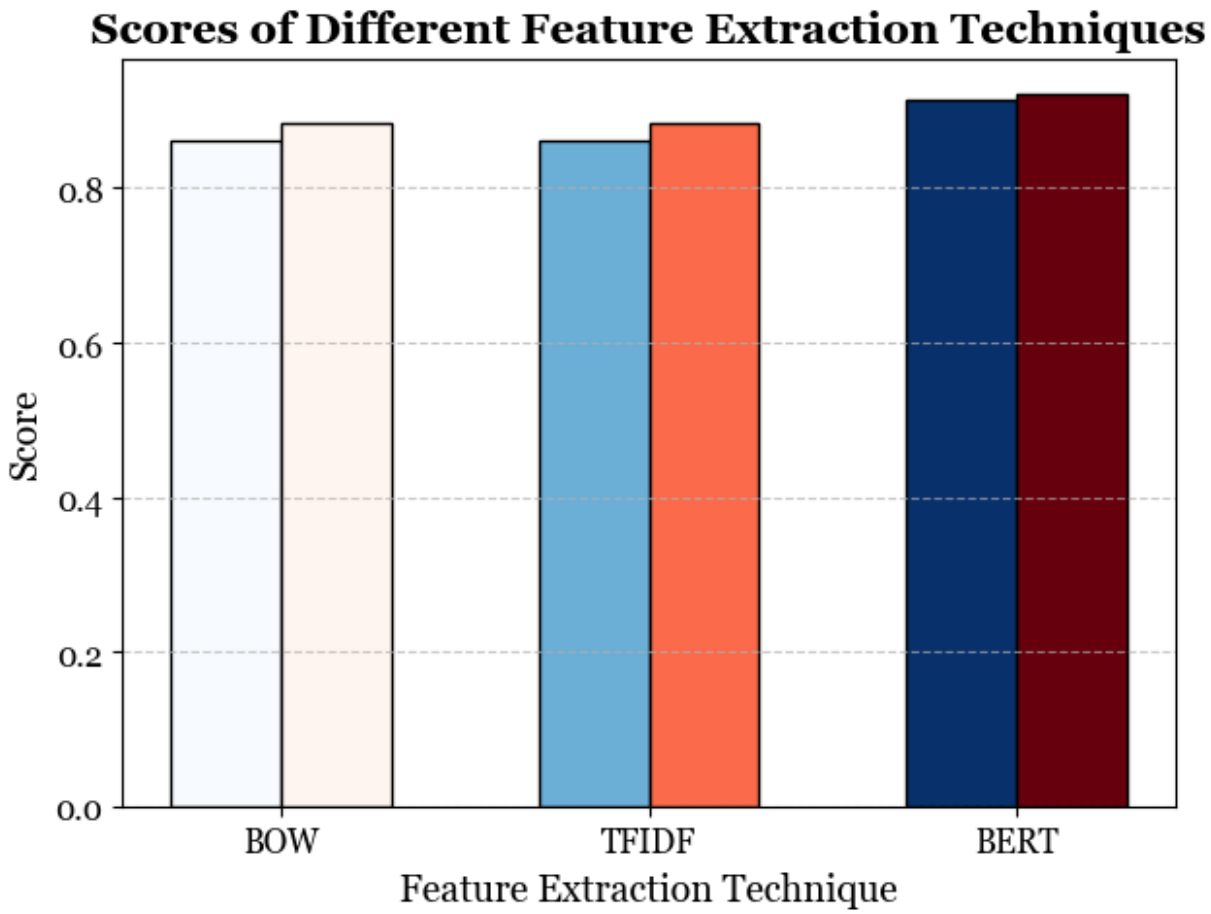

```
Accuracy - BERT:  0.9137931034482759
F1 Score - BERT:  0.9216760933580791
Classification Report - BERT:
              precision    recall  f1-score   support

           0       0.56      1.00      0.71         5
           1       1.00      0.94      0.97        16
           2       1.00      0.90      0.95        20
           3       0.94      0.88      0.91        17

    accuracy                           0.91        58
   macro avg       0.87      0.93      0.88        58
```

```
weighted avg       0.94      0.91      0.92        58


  Feature Extraction Technique  Accuracy  F1 Score
0                         BOW  0.862069  0.883570
1                       TFIDF  0.862069  0.883570
2                        BERT  0.913793  0.921676
```

```python
import matplotlib.pyplot as plt
import numpy as np
import matplotlib.cm as cm  # To generate a colormap

# Assuming df_scores is a pandas DataFrame with columns 'Feature
Extraction Technique', 'Accuracy', and 'F1 Score'

# Generate positions for grouped bars
x = np.arange(len(df_scores['Feature Extraction Technique']))  # the
label locations
width = 0.3  # width of the bars

# Generate a colormap for varied colors
colors_accuracy = cm.get_cmap('Blues', len(df_scores))
colors_f1 = cm.get_cmap('Reds', len(df_scores))

plt.figure(figsize=(7, 5))

# Plot bars for Accuracy with borders and varied colors
for i in range(len(x)):
    plt.bar(
        x[i] - width/2, df_scores['Accuracy'][i], width,
        color=colors_accuracy(i / len(x)), edgecolor='black',
label='Accuracy' if i == 0 else ""
    )

# Plot bars for F1 Score with borders and varied colors
for i in range(len(x)):
    plt.bar(
        x[i] + width/2, df_scores['F1 Score'][i], width,
        color=colors_f1(i / len(x)), edgecolor='black', label='F1
Score' if i == 0 else ""
    )

# Add gridlines
plt.grid(axis='y', linestyle='--', alpha=0.7)

# Add labels and title
plt.title('Scores of Different Feature Extraction Techniques',
fontname='Georgia', fontsize=16, fontweight='bold')
plt.xlabel('Feature Extraction Technique', fontname='Georgia',
fontsize=14)
plt.ylabel('Score', fontname='Georgia', fontsize=14)
```

```
# Add x-ticks with labels
plt.xticks(x, df_scores['Feature Extraction Technique'],
fontname='Georgia', fontsize=12)

# Add y-ticks
plt.yticks(fontname='Georgia', fontsize=12)



# Show the plot
plt.show()
```

```
C:\Users\itzch\AppData\Local\Temp\ipykernel_8512\57170953.py:12:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in
Matplotlib 3.7 and will be removed in 3.11. Use
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap()``
or ``pyplot.get_cmap()`` instead.
  colors_accuracy = cm.get_cmap('Blues', len(df_scores))
C:\Users\itzch\AppData\Local\Temp\ipykernel_8512\57170953.py:13:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in
Matplotlib 3.7 and will be removed in 3.11. Use
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap()``
or ``pyplot.get_cmap()`` instead.
  colors_f1 = cm.get_cmap('Reds', len(df_scores))
```



Classifier - ID3

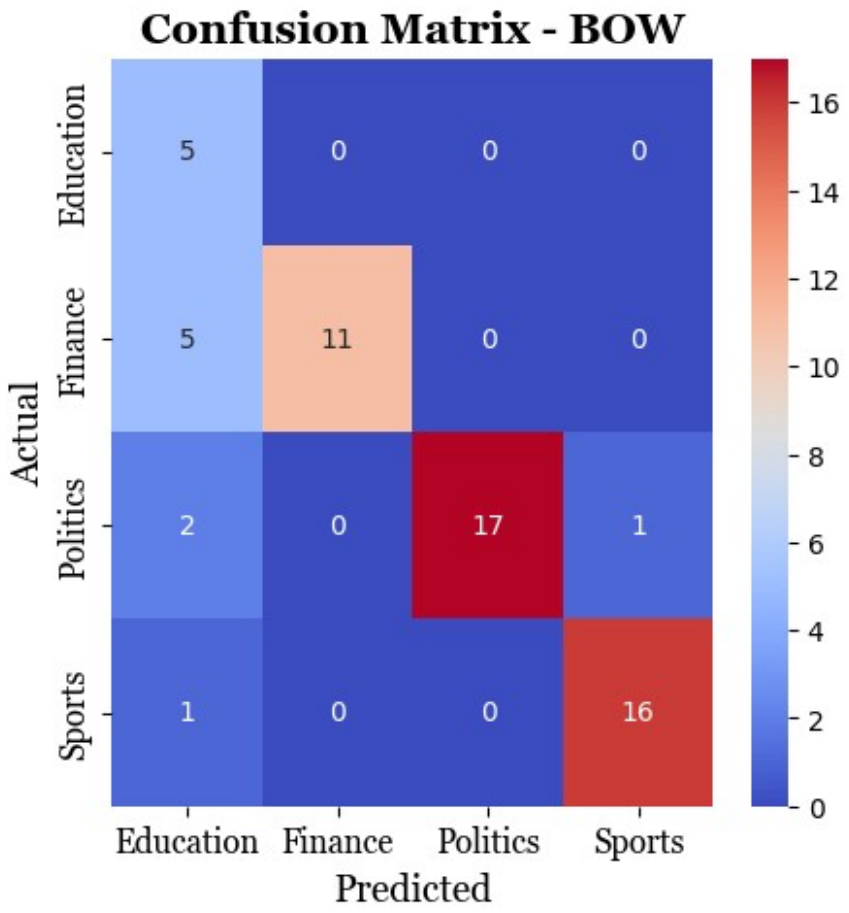
```
#same process with ID3
from sklearn.tree import DecisionTreeClassifier

dt1 = DecisionTreeClassifier()
dt1.fit(X_train_BOW, y_train_BOW)

dt2 = DecisionTreeClassifier()
dt2.fit(X_train_TFIDF, y_train_TFIDF)

dt3 = DecisionTreeClassifier()
dt3.fit(X_train_BERT, y_train_BERT)

#Evaluation - accuracy, f1 score, confusion matrix, classification
report
from sklearn.metrics import accuracy_score, f1_score,
confusion_matrix, classification_report

#BOW-----------------------------------------------------------------
-----------------------------------------------
y_pred_BOW = dt1.predict(X_test_BOW)
```

```
accuracy_BOW = accuracy_score(y_test_BOW, y_pred_BOW)
f1_BOW = f1_score(y_test_BOW, y_pred_BOW, average='weighted')
conf_matrix_BOW = confusion_matrix(y_test_BOW, y_pred_BOW)
class_report_BOW = classification_report(y_test_BOW, y_pred_BOW)

#Confusion Matrix as heatmap wth seaborn and annot=True
import seaborn as sns
plt.figure(figsize=(5,5))
sns.heatmap(conf_matrix_BOW, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - BOW', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)

plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

#display scores
print("Accuracy - BOW: ", accuracy_BOW)
print("F1 Score - BOW: ", f1_BOW)
print("Classification Report - BOW: \n", class_report_BOW)

#TFIDF-----------------------------------------------------------------
----------------------------
y_pred_TFIDF = dt2.predict(X_test_TFIDF)
accuracy_TFIDF = accuracy_score(y_test_TFIDF, y_pred_TFIDF)
f1_TFIDF = f1_score(y_test_TFIDF, y_pred_TFIDF, average='weighted')
conf_matrix_TFIDF = confusion_matrix(y_test_TFIDF, y_pred_TFIDF)

class_report_TFIDF = classification_report(y_test_TFIDF, y_pred_TFIDF)

#Confusion Matrix as heatmap wth seaborn and annot=True
import seaborn as sns
plt.figure(figsize=(5,5))
sns.heatmap(conf_matrix_TFIDF, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - TFIDF', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

#display scores
print("Accuracy - TFIDF: ", accuracy_TFIDF)
print("F1 Score - TFIDF: ", f1_TFIDF)
print("Classification Report - TFIDF: \n", class_report_TFIDF)
```

```
#BERT-----------------------------------------------------------------
-------------------------------------------------------------
y_pred_BERT = dt3.predict(X_test_BERT)
accuracy_BERT = accuracy_score(y_test_BERT, y_pred_BERT)
f1_BERT = f1_score(y_test_BERT, y_pred_BERT, average='weighted')
conf_matrix_BERT = confusion_matrix(y_test_BERT, y_pred_BERT)

class_report_BERT = classification_report(y_test_BERT, y_pred_BERT)

#Confusion Matrix as heatmap wth seaborn and annot=True
import seaborn as sns
plt.figure(figsize=(5,5))
sns.heatmap(conf_matrix_BERT, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - BERT', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

#display scores
print("Accuracy - BERT: ", accuracy_BERT)
print("F1 Score - BERT: ", f1_BERT)
print("Classification Report - BERT: \n", class_report_BERT)

#Display the scores in a table and the best feature extraction
technique
import pandas as pd

data = {
    'Feature Extraction Technique': ['BOW', 'TFIDF', 'BERT'],
    'Accuracy': [accuracy_BOW, accuracy_TFIDF, accuracy_BERT],
    'F1 Score': [f1_BOW, f1_TFIDF, f1_BERT]
}

df_scores = pd.DataFrame(data)

#best model with feature extraciton technique

best_model = df_scores.loc[df_scores['F1 Score'].idxmax()]
print(best_model)

df_scores.head()

import matplotlib.pyplot as plt
```

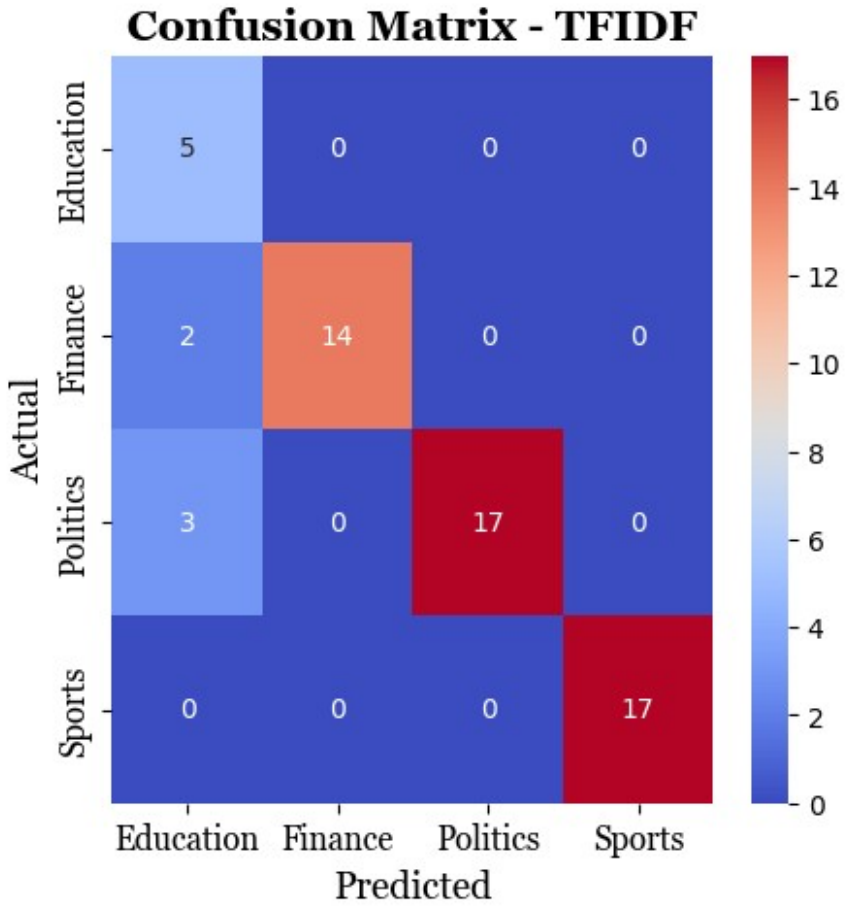
```
import numpy as np
import matplotlib.cm as cm  # To generate a colormap

# Assuming df_scores is a pandas DataFrame with columns 'Feature
Extraction Technique', 'Accuracy', and 'F1 Score'

# Generate positions for grouped bars
x = np.arange(len(df_scores['Feature Extraction Technique']))  # the
label locations
width = 0.4  # width of the bars

# Generate a colormap for varied colors
colors_accuracy = cm.get_cmap('Blues', len(df_scores))
colors_f1 = cm.get_cmap('Reds', len(df_scores))

plt.figure(figsize=(7, 5))

# Plot bars for Accuracy with borders and varied colors

for i in range(len(x)):
    plt.bar(
        x[i] - width/2, df_scores['Accuracy'][i], width,
        color=colors_accuracy(i / len(x)), edgecolor='black',
label='Accuracy' if i == 0 else ""
    )

# Plot bars for F1 Score with borders and varied colors
for i in range(len(x)):
    plt.bar(
        x[i] + width/2, df_scores['F1 Score'][i], width,
        color=colors_f1(i / len(x)), edgecolor='black', label='F1
Score' if i == 0 else ""
    )

# Add gridlines
plt.grid(axis='y', linestyle='--', alpha=0.7)

# Add labels and title
plt.title('Scores of Different Feature Extraction Techniques',
fontname='Georgia', fontsize=16, fontweight='bold')
plt.xlabel('Feature Extraction Technique', fontname='Georgia',
fontsize=14)
plt.ylabel('Score', fontname='Georgia', fontsize=14)

# Add x-ticks with labels
plt.xticks(x, df_scores['Feature Extraction Technique'],
fontname='Georgia', fontsize=12)

# Add y-ticks
```

```
plt.yticks(fontname='Georgia', fontsize=12)

# Show the plot
plt.show()

df_scores.head()
```

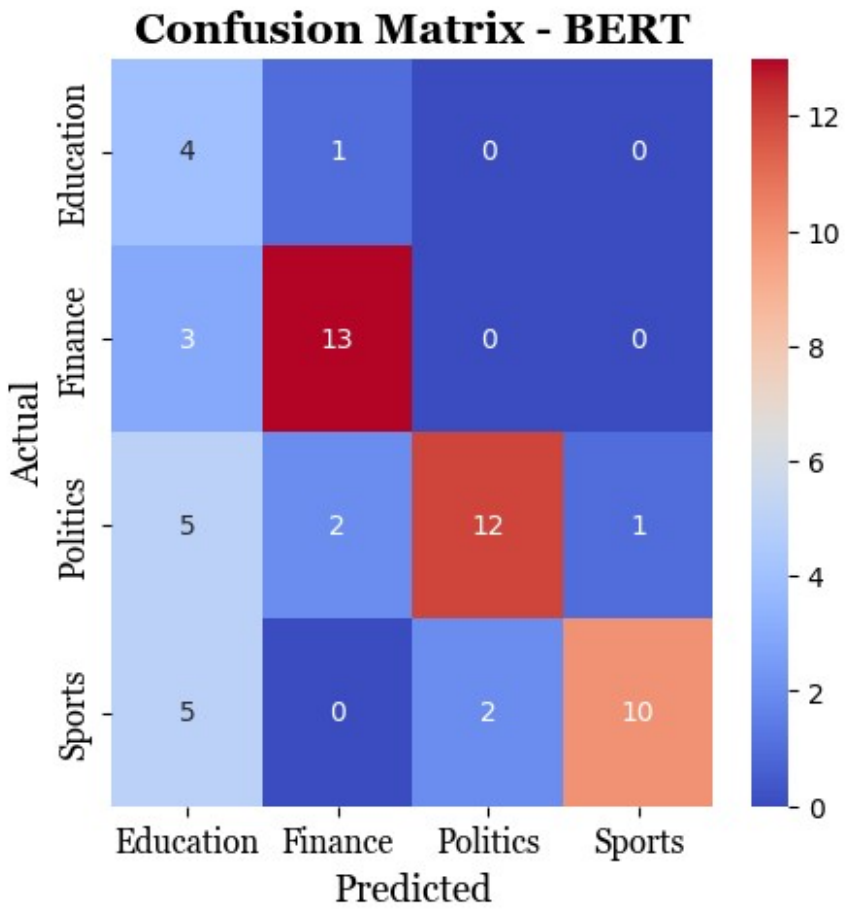



```
Accuracy - BOW:  0.8448275862068966
F1 Score - BOW:  0.865399882641262
Classification Report - BOW:
              precision    recall  f1-score   support

           0       0.38      1.00      0.56         5
           1       1.00      0.69      0.81        16
           2       1.00      0.85      0.92        20
           3       0.94      0.94      0.94        17

    accuracy                           0.84        58
   macro avg       0.83      0.87      0.81        58
```

```
weighted avg       0.93      0.84      0.87        58
```

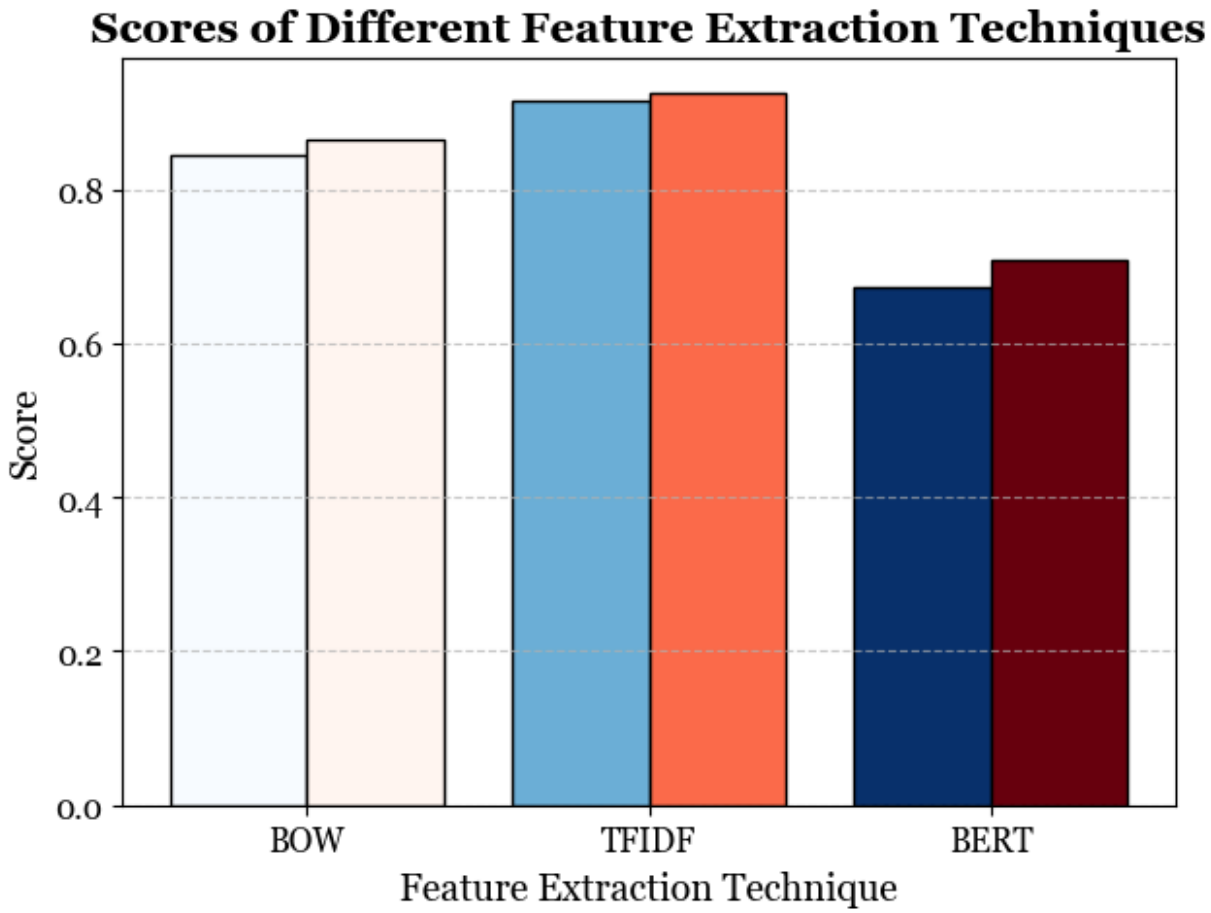



```
Accuracy - TFIDF:  0.9137931034482759
F1 Score - TFIDF:  0.9249145697421559
Classification Report - TFIDF:
               precision    recall  f1-score   support

           0       0.50      1.00      0.67         5
           1       1.00      0.88      0.93        16
           2       1.00      0.85      0.92        20
           3       1.00      1.00      1.00        17

    accuracy                           0.91        58
   macro avg       0.88      0.93      0.88        58
weighted avg       0.96      0.91      0.92        58
```




```
Accuracy - BERT:  0.6724137931034483
F1 Score - BERT:  0.7082532072390084
Classification Report - BERT:
              precision    recall  f1-score   support

           0       0.24      0.80      0.36         5
           1       0.81      0.81      0.81        16
           2       0.86      0.60      0.71        20
           3       0.91      0.59      0.71        17

    accuracy                           0.67        58
   macro avg       0.70      0.70      0.65        58
weighted avg       0.81      0.67      0.71        58

Feature Extraction Technique       TFIDF
Accuracy                        0.913793
F1 Score                        0.924915
Name: 1, dtype: object

C:\Users\itzch\AppData\Local\Temp\ipykernel_8512\2517349125.py:121:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in
Matplotlib 3.7 and will be removed in 3.11. Use
```

```
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap()``
or ``pyplot.get_cmap()`` instead.
  colors_accuracy = cm.get_cmap('Blues', len(df_scores))
C:\Users\itzch\AppData\Local\Temp\ipykernel_8512\2517349125.py:122:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in
Matplotlib 3.7 and will be removed in 3.11. Use
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap()``
or ``pyplot.get_cmap()`` instead.
  colors_f1 = cm.get_cmap('Reds', len(df_scores))
```




```
  Feature Extraction Technique  Accuracy  F1 Score
0                          BOW  0.844828  0.865400
1                        TFIDF  0.913793  0.924915
2                         BERT  0.672414  0.708253
```

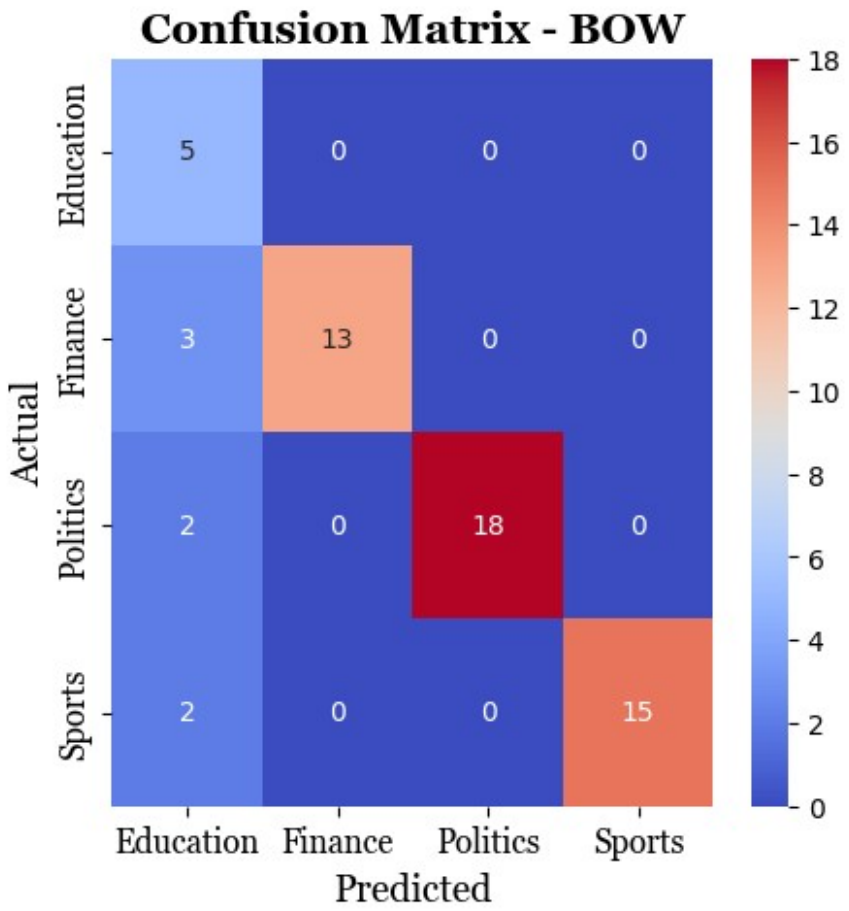
Classifier - Random Forest

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, f1_score,
confusion_matrix, classification_report
import seaborn as sns
```

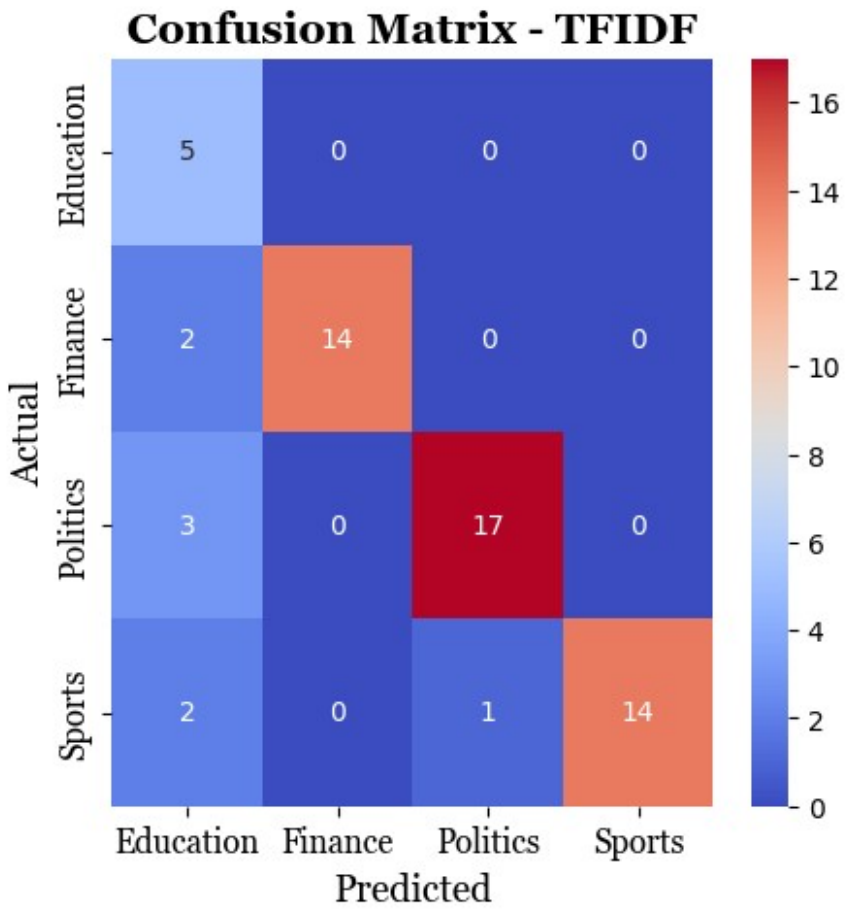
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import matplotlib.cm as cm  # To generate a colormap

# Random Forest Classifier
rf1 = RandomForestClassifier(random_state=42)
rf1.fit(X_train_BOW, y_train_BOW)

rf2 = RandomForestClassifier(random_state=42)
rf2.fit(X_train_TFIDF, y_train_TFIDF)

rf3 = RandomForestClassifier(random_state=42)
rf3.fit(X_train_BERT, y_train_BERT)

# Evaluation - Accuracy, F1 Score, Confusion Matrix, Classification
Report

# BOW
y_pred_BOW = rf1.predict(X_test_BOW)
accuracy_BOW = accuracy_score(y_test_BOW, y_pred_BOW)
f1_BOW = f1_score(y_test_BOW, y_pred_BOW, average='weighted')
conf_matrix_BOW = confusion_matrix(y_test_BOW, y_pred_BOW)
class_report_BOW = classification_report(y_test_BOW, y_pred_BOW)

plt.figure(figsize=(5, 5))
sns.heatmap(conf_matrix_BOW, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - BOW', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

print("Accuracy - BOW: ", accuracy_BOW)
print("F1 Score - BOW: ", f1_BOW)
print("Classification Report - BOW: \n", class_report_BOW)

# TFIDF
y_pred_TFIDF = rf2.predict(X_test_TFIDF)
accuracy_TFIDF = accuracy_score(y_test_TFIDF, y_pred_TFIDF)
f1_TFIDF = f1_score(y_test_TFIDF, y_pred_TFIDF, average='weighted')
conf_matrix_TFIDF = confusion_matrix(y_test_TFIDF, y_pred_TFIDF)
class_report_TFIDF = classification_report(y_test_TFIDF, y_pred_TFIDF)

plt.figure(figsize=(5, 5))
sns.heatmap(conf_matrix_TFIDF, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
```

```
plt.title('Confusion Matrix - TFIDF', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

print("Accuracy - TFIDF: ", accuracy_TFIDF)
print("F1 Score - TFIDF: ", f1_TFIDF)
print("Classification Report - TFIDF: \n", class_report_TFIDF)

# BERT
y_pred_BERT = rf3.predict(X_test_BERT)
accuracy_BERT = accuracy_score(y_test_BERT, y_pred_BERT)
f1_BERT = f1_score(y_test_BERT, y_pred_BERT, average='weighted')
conf_matrix_BERT = confusion_matrix(y_test_BERT, y_pred_BERT)
class_report_BERT = classification_report(y_test_BERT, y_pred_BERT)

plt.figure(figsize=(5, 5))
sns.heatmap(conf_matrix_BERT, annot=True, fmt='d', cmap='coolwarm',
xticklabels=encoder.classes_, yticklabels=encoder.classes_)
plt.title('Confusion Matrix - BERT', fontname='Georgia', fontsize=16,
fontweight='bold')
plt.xlabel('Predicted', fontname='Georgia', fontsize=14)
plt.ylabel('Actual', fontname='Georgia', fontsize=14)
plt.xticks(fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)
plt.show()

print("Accuracy - BERT: ", accuracy_BERT)
print("F1 Score - BERT: ", f1_BERT)
print("Classification Report - BERT: \n", class_report_BERT)

# Display Scores in a Table
data = {
    'Feature Extraction Technique': ['BOW', 'TFIDF', 'BERT'],
    'Accuracy': [accuracy_BOW, accuracy_TFIDF, accuracy_BERT],
    'F1 Score': [f1_BOW, f1_TFIDF, f1_BERT]
}

df_scores = pd.DataFrame(data)

# Identify the best model
best_model = df_scores.loc[df_scores['F1 Score'].idxmax()]
print("Best Feature Extraction Technique:\n", best_model)

# Display Scores in Graphical Format
x = np.arange(len(df_scores['Feature Extraction Technique']))
width = 0.4
```

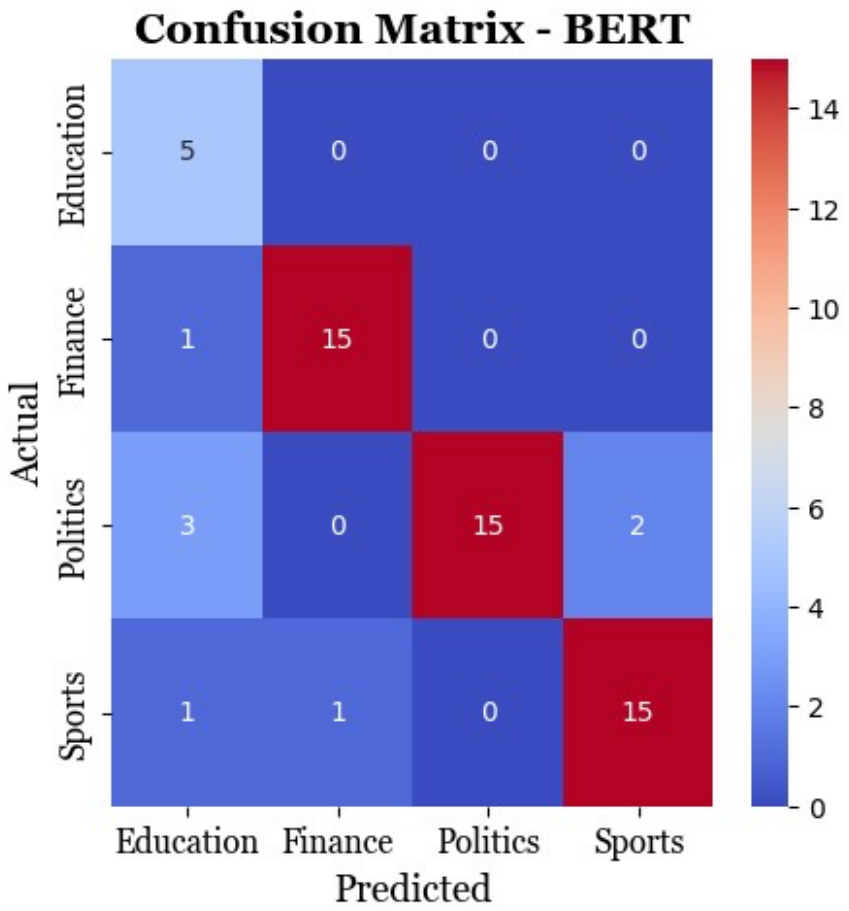
```
colors_accuracy = cm.get_cmap('Blues', len(df_scores))
colors_f1 = cm.get_cmap('Reds', len(df_scores))

plt.figure(figsize=(7, 5))

# Plot Accuracy Bars
for i in range(len(x)):
    plt.bar(
        x[i] - width/2, df_scores['Accuracy'][i], width,
        color=colors_accuracy(i / len(x)), edgecolor='black',
label='Accuracy' if i == 0 else ""
    )

# Plot F1 Score Bars
for i in range(len(x)):
    plt.bar(
        x[i] + width/2, df_scores['F1 Score'][i], width,
        color=colors_f1(i / len(x)), edgecolor='black', label='F1
Score' if i == 0 else ""
    )

plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.title('Scores of Different Feature Extraction Techniques',
fontname='Georgia', fontsize=16, fontweight='bold')
plt.xlabel('Feature Extraction Technique', fontname='Georgia',
fontsize=14)
plt.ylabel('Score', fontname='Georgia', fontsize=14)
plt.xticks(x, df_scores['Feature Extraction Technique'],
fontname='Georgia', fontsize=12)
plt.yticks(fontname='Georgia', fontsize=12)

plt.show()
```




```
Accuracy - BOW:  0.8793103448275862
F1 Score - BOW:  0.8994978013422028
Classification Report - BOW:
              precision    recall  f1-score   support

           0       0.42      1.00      0.59         5
           1       1.00      0.81      0.90        16
           2       1.00      0.90      0.95        20
           3       1.00      0.88      0.94        17

    accuracy                           0.88        58
   macro avg       0.85      0.90      0.84        58
weighted avg       0.95      0.88      0.90        58
```

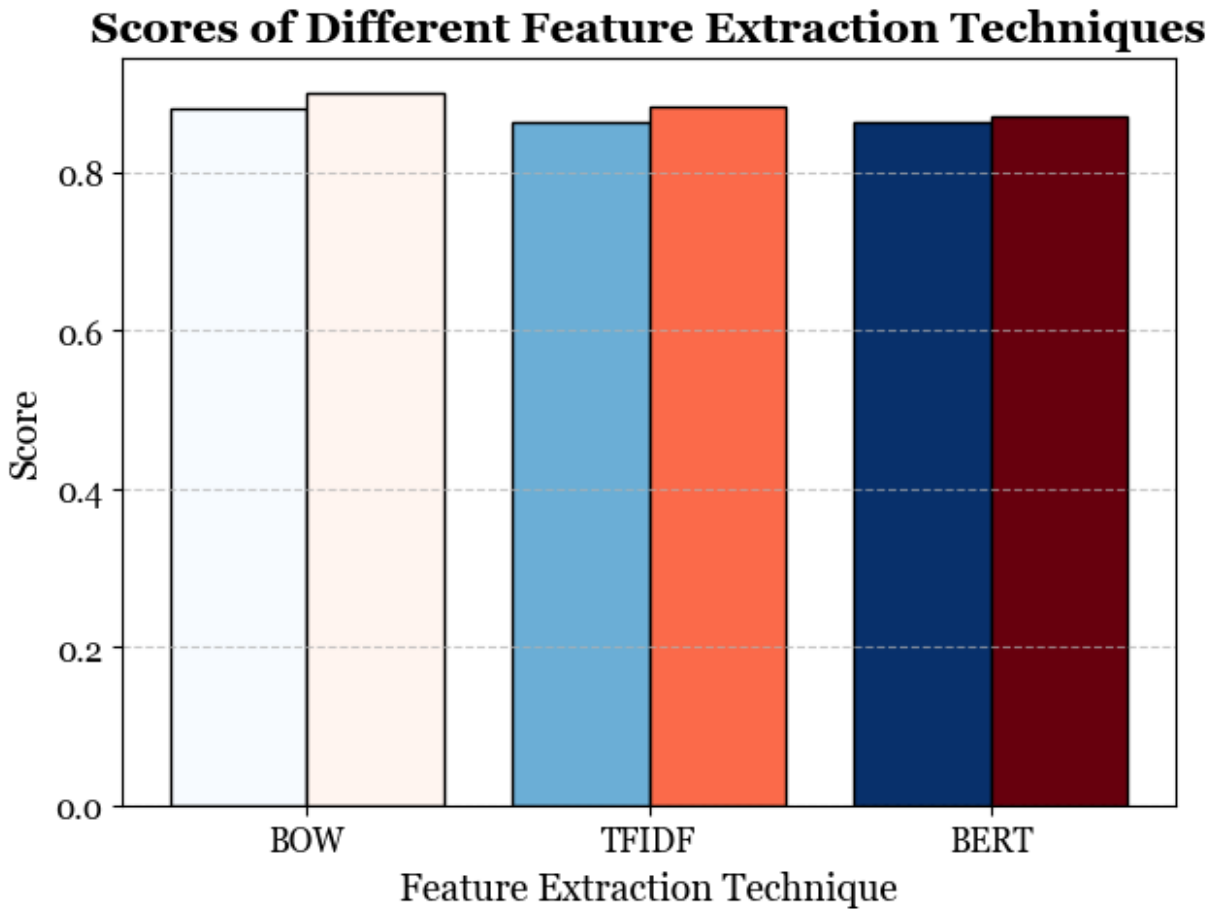



```
Accuracy - TFIDF:  0.8620689655172413
F1 Score - TFIDF:  0.8814497475121421
Classification Report - TFIDF:
              precision    recall  f1-score   support

           0       0.42      1.00      0.59         5
           1       1.00      0.88      0.93        16
           2       0.94      0.85      0.89        20
           3       1.00      0.82      0.90        17

    accuracy                           0.86        58
   macro avg       0.84      0.89      0.83        58
weighted avg       0.93      0.86      0.88        58
```




```
Accuracy - BERT:  0.8620689655172413
F1 Score - BERT:  0.870279146141215
Classification Report - BERT:
              precision    recall  f1-score   support

           0       0.50      1.00      0.67         5
           1       0.94      0.94      0.94        16
           2       1.00      0.75      0.86        20
           3       0.88      0.88      0.88        17

    accuracy                           0.86        58
   macro avg       0.83      0.89      0.84        58
weighted avg       0.91      0.86      0.87        58

Best Feature Extraction Technique:
 Feature Extraction Technique         BOW
Accuracy                          0.87931
F1 Score                         0.899498
Name: 0, dtype: object

C:\Users\itzch\AppData\Local\Temp\ipykernel_8512\246849643.py:97:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in
```

```
Matplotlib 3.7 and will be removed in 3.11. Use
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap()``
or ``pyplot.get_cmap()`` instead.
  colors_accuracy = cm.get_cmap('Blues', len(df_scores))
C:\Users\itzch\AppData\Local\Temp\ipykernel_8512\246849643.py:98:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in
Matplotlib 3.7 and will be removed in 3.11. Use
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap()``
or ``pyplot.get_cmap()`` instead.
  colors_f1 = cm.get_cmap('Reds', len(df_scores))
```



Classifier - Word Embedding with LSTM

```
```