In [126…
```
import pandas as pd
import numpy as np
from sklearn.model_selection import KFold
spotify = pd.read_csv('dataset.csv')
```

In [127…
```
spotify.head(10)
```

Out[127]:

	Unnamed: 0	track_id	artists	album_name	track_name	popularity	duration_ms
0	0	5SuOikwiRyPMVoIQDJUgSV	Gen Hoshino	Comedy	Comedy	73	230666
1	1	4qPNDBW1i3p13qLCt0Ki3A	Ben Woodward	Ghost (Acoustic)	Ghost - Acoustic	55	149610
2	2	1iJBSr7s7jYXzM8EGcbK5b	Ingrid Michaelson;ZAYN	To Begin Again	To Begin Again	57	210826
3	3	6lfxq3CG4xtTiEg7opyCyx	Kina Grannis	Crazy Rich Asians (Original Motion Picture Sou...	Can't Help Falling In Love	71	201933
4	4	5vjLSffimiIP26QG5WcN2K	Chord Overstreet	Hold On	Hold On	82	198853
5	5	01MVOl9KtVTNfFiBU9I7dc	Tyrone Wells	Days I Will Remember	Days I Will Remember	58	214240
6	6	6Vc5wAMmXdKIAM7WUoEb7N	A Great Big World;Christina Aguilera	Is There Anybody Out There?	Say Something	74	229400
7	7	1EzrEOXmMH3G43AXT1y7pA	Jason Mraz	We Sing. We Dance. We Steal Things.	I'm Yours	80	242946
8	8	0IktbUcnAGrvD03AWnz3Q8	Jason Mraz;Colbie Caillat	We Sing. We Dance. We Steal Things.	Lucky	74	189613
9	9	7k9GuJYLp2AzqokyEdwEw2	Ross Copperman	Hunger	Hunger	56	205594

10 rows × 21 columns

In [128…
```
spotify.describe()
```

Out[128]:

	Unnamed: 0	popularity	duration_ms	danceability	energy	key	loudness
count	114000.000000	114000.000000	1.140000e+05	114000.000000	114000.000000	114000.000000	114000.000000
mean	56999.500000	33.238535	2.280292e+05	0.566800	0.641383	5.309140	-8.258960
std	32909.109681	22.305078	1.072977e+05	0.173542	0.251529	3.559987	5.029337
min	0.000000	0.000000	0.000000e+00	0.000000	0.000000	0.000000	-49.531000
25%	28499.750000	17.000000	1.740660e+05	0.456000	0.472000	2.000000	-10.013000
50%	56999.500000	35.000000	2.129060e+05	0.580000	0.685000	5.000000	-7.004000
75%	85499.250000	50.000000	2.615060e+05	0.695000	0.854000	8.000000	-5.003000
max	113999.000000	100.000000	5.237295e+06	0.985000	1.000000	11.000000	4.532000

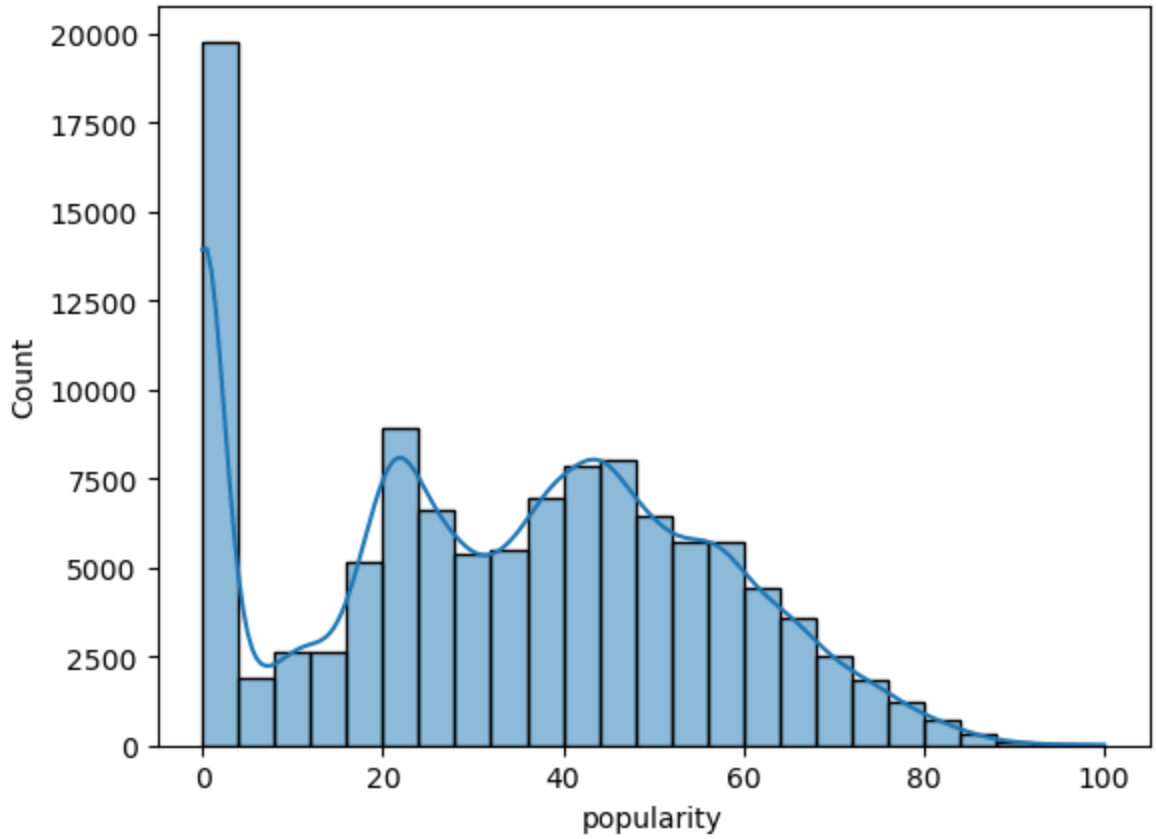
In [129…
```
spotify.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 114000 entries, 0 to 113999
Data columns (total 21 columns):
 #   Column            Non-Null Count   Dtype  
---  ------            --------------   -----  
 0   Unnamed: 0        114000 non-null  int64  
 1   track_id          114000 non-null  object 
 2   artists           113999 non-null  object 
 3   album_name        113999 non-null  object 
 4   track_name        113999 non-null  object 
 5   popularity        114000 non-null  int64  
 6   duration_ms       114000 non-null  int64  
 7   explicit          114000 non-null  bool   
 8   danceability      114000 non-null  float64
 9   energy            114000 non-null  float64
 10  key               114000 non-null  int64  
 11  loudness          114000 non-null  float64
 12  mode              114000 non-null  int64  
 13  speechiness       114000 non-null  float64
 14  acousticness      114000 non-null  float64
 15  instrumentalness  114000 non-null  float64
 16  liveness          114000 non-null  float64
 17  valence           114000 non-null  float64
 18  tempo             114000 non-null  float64
 19  time_signature    114000 non-null  int64  
 20  track_genre       114000 non-null  object 
dtypes: bool(1), float64(9), int64(6), object(5)
memory usage: 17.5+ MB
```

In [130…
```
from scipy.stats import skew
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

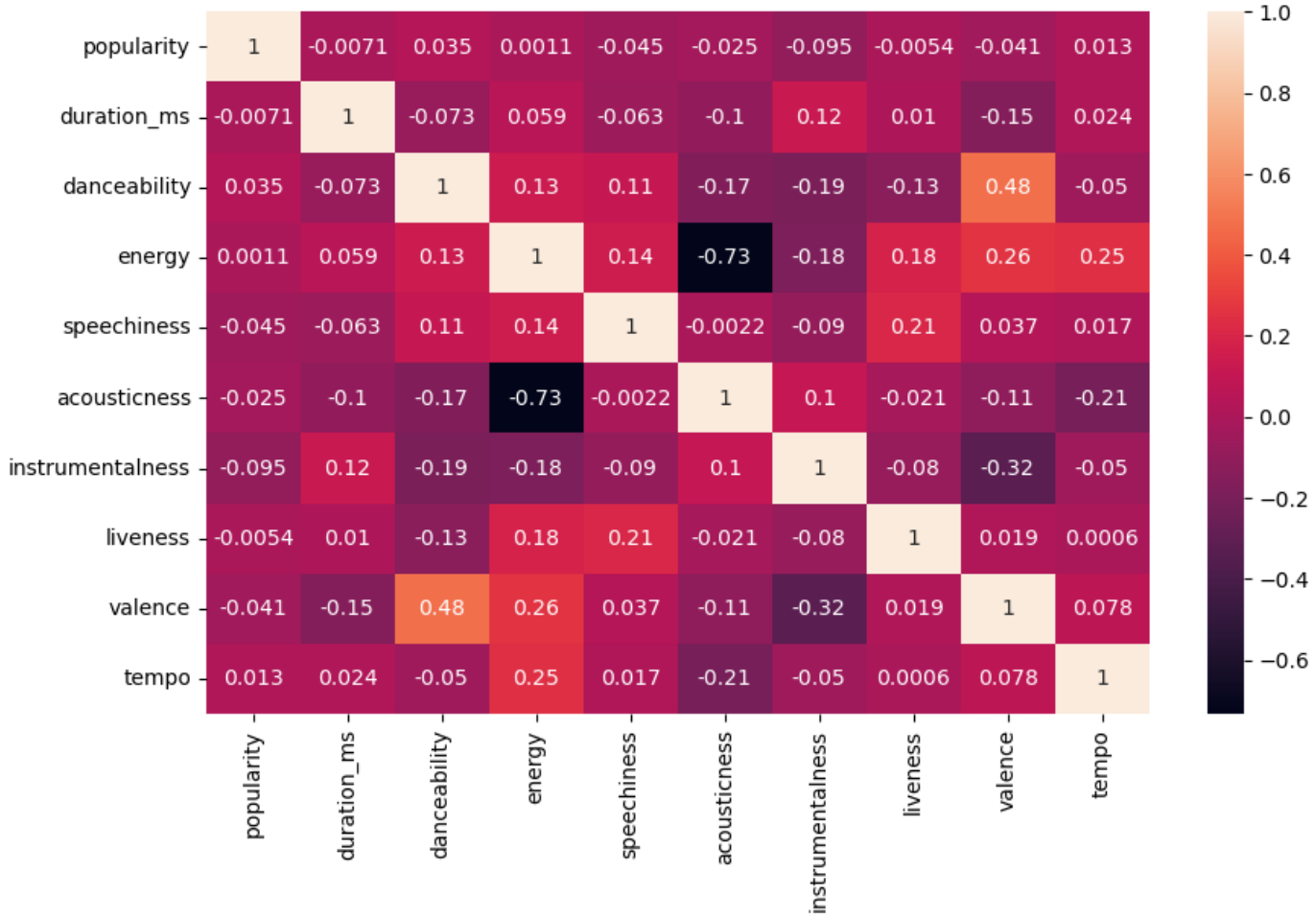
In [131…
```
dataset=spotify.copy()
print(spotify['popularity'], 'skewness is :', skew(dataset['popularity']))
sns.histplot(x='popularity', data=dataset, bins=25, kde=True)
plt.show()
```

```
0         73
1         55
2         57
3         71
4         82
          ..
113995    21
113996    22
113997    22
113998    41
113999    22
Name: popularity, Length: 114000, dtype: int64 skewness is : 0.04640190527012667
```



In [132…
```
combined = ['popularity','duration_ms', 'danceability', 'energy', 'speechiness', 'acoust
```

In [133…
```
dataset=spotify.copy()
plt.figure(figsize=(10,6))
sns.heatmap(spotify[combined].corr(), annot=True)
plt.show()
```



In [134…

```
# Normalization process
numerical_features = ['duration_ms', 'danceability', 'energy', 'speechiness', 'acousticn
target_feature = 'popularity'

spotify[numerical_features] = (spotify[numerical_features] - spotify[numerical_features]
spotify[target_feature] = (spotify[target_feature] - spotify[target_feature].min()) / (s

# Converting the data to 64-bit
spotify[numerical_features] = spotify[numerical_features].astype('float64')
spotify[target_feature] = spotify[target_feature].astype('float64')

# Gradient clipping using 0.5 threshold
spotify[numerical_features] = np.clip(spotify[numerical_features], 0, 0.5)

X = spotify[numerical_features].values
y = spotify[target_feature].values
```

In [135…

```
# Ridge Regression function
def ridge_regression(X, y, alpha, learning_rate, num_iterations):
    m, n = X.shape
    weights = np.zeros(n)
    for i in range(num_iterations):
        # Calculate predictions and error
        predictions = np.dot(X, weights)
        error = predictions - y

        # Compute gradient and update weights
        gradient = 2/m * (np.dot(X.T, error) + alpha * weights)
        weights -= learning_rate * gradient

    return weights
```

In [136…

```
from sklearn.metrics import mean_absolute_error
```

```
def k_fold_cross_validation(X, y, alpha, learning_rate, num_iterations, num_folds=5):
    kf = KFold(n_splits=num_folds)
    mse_scores = []
    mae_scores = []

    for train_index, test_index in kf.split(X):
        X_train, X_test = X[train_index], X[test_index]
        y_train, y_test = y[train_index], y[test_index]

        # Trainining
        weights = ridge_regression(X_train, y_train, alpha, learning_rate, num_iteration

        #  mean squared error
        predictions = np.dot(X_test, weights)
        mse = np.mean((predictions - y_test) ** 2)
        mse_scores.append(mse)

        #  Mean absolute error
        mae = mean_absolute_error(y_test, predictions)
        mae_scores.append(mae)


    avg_mse = np.mean(mse_scores)
    avg_mae = np.mean(mae_scores)
    return avg_mse, avg_mae


alpha = 10
learning_rate = 0.001
num_iterations = 10000

# Appllying the algortihm
avg_mse, avg_mae = k_fold_cross_validation(X, y, alpha, learning_rate, num_iterations, n

# results
print("Mean squared error:", avg_mse)
print("Mean absolute error:", avg_mae)
```

```
Mean squared error: 0.05108363768221352
Mean absolute error: 0.18996849886361447
```

In [137…
```
categorical_features = ['explicit', 'time_signature', 'track_genre', 'key']
```

In [138…
```
spotify[categorical_features]
```

Out[138]:

	explicit	time_signature	track_genre	key
0	False	4	acoustic	1
1	False	4	acoustic	1
2	False	4	acoustic	0
3	False	3	acoustic	0
4	False	4	acoustic	2
...	...	...	...	...
113995	False	5	world-music	5
113996	False	4	world-music	0
113997	False	4	world-music	0
113998	False	4	world-music	7

113999	False	4	world-music	1

114000 rows × 4 columns

In [139…
```
spotify[categorical_features].describe()
```

Out[139]:

	time_signature	key
count	114000.000000	114000.000000
mean	3.904035	5.309140
std	0.432621	3.559987
min	0.000000	0.000000
25%	4.000000	2.000000
50%	4.000000	5.000000
75%	4.000000	8.000000
max	5.000000	11.000000

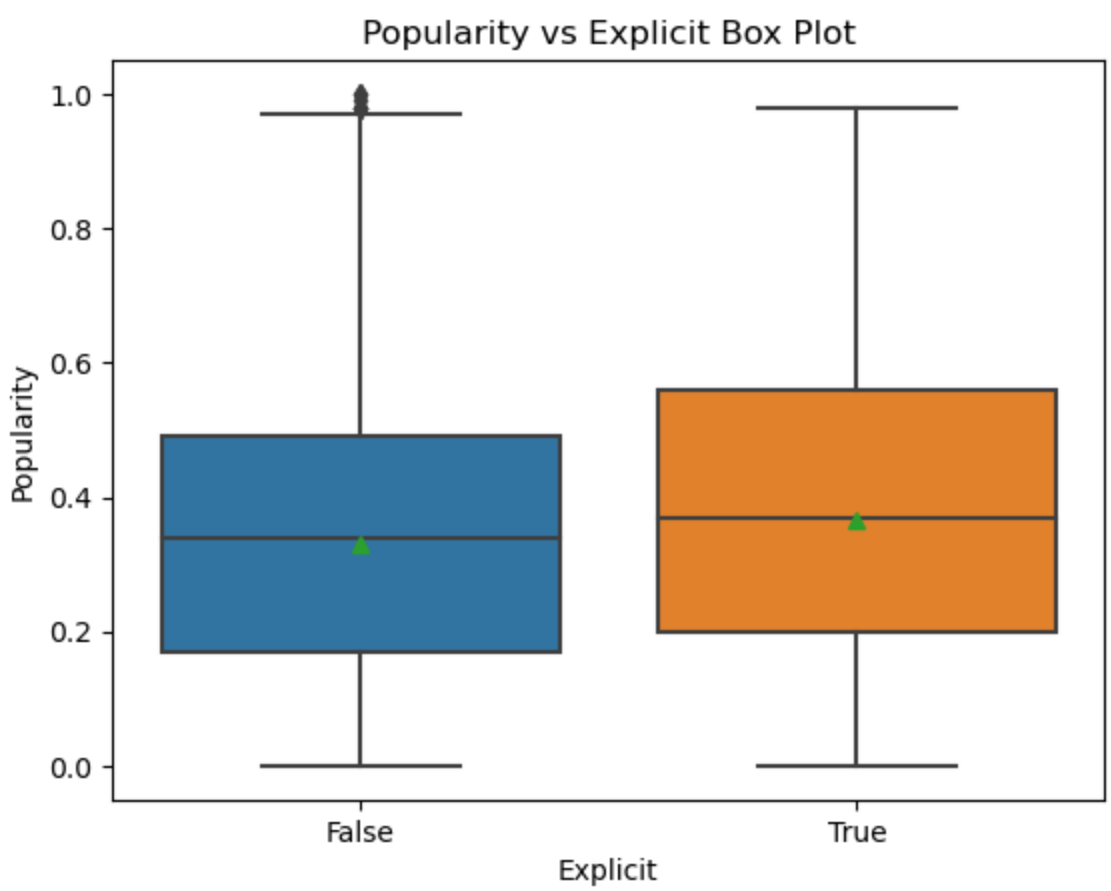
In [140…
```
import pandas as pd
import matplotlib.pyplot as plt
```

In [141…
```
import seaborn as sns

sns.boxplot(
    x = 'explicit',
    y = 'popularity',
    showmeans=True,
    data=spotify
)

plt.title('Popularity vs Explicit Box Plot')
plt.xlabel('Explicit')
plt.ylabel('Popularity')

plt.show()
```



In [142…
```
import pandas as pd
mean_popularity_by_explicit = spotify.groupby('explicit')['popularity'].mean()


print(mean_popularity_by_explicit)
```

```
explicit
False    0.329379
True     0.364542
Name: popularity, dtype: float64
```

In [143…
```
explicit_to_popularity_mean_mapping = dict(zip(mean_popularity_by_explicit.index, mean_p
spotify['explicit'] = spotify['explicit'].replace(explicit_to_popularity_mean_mapping)
```

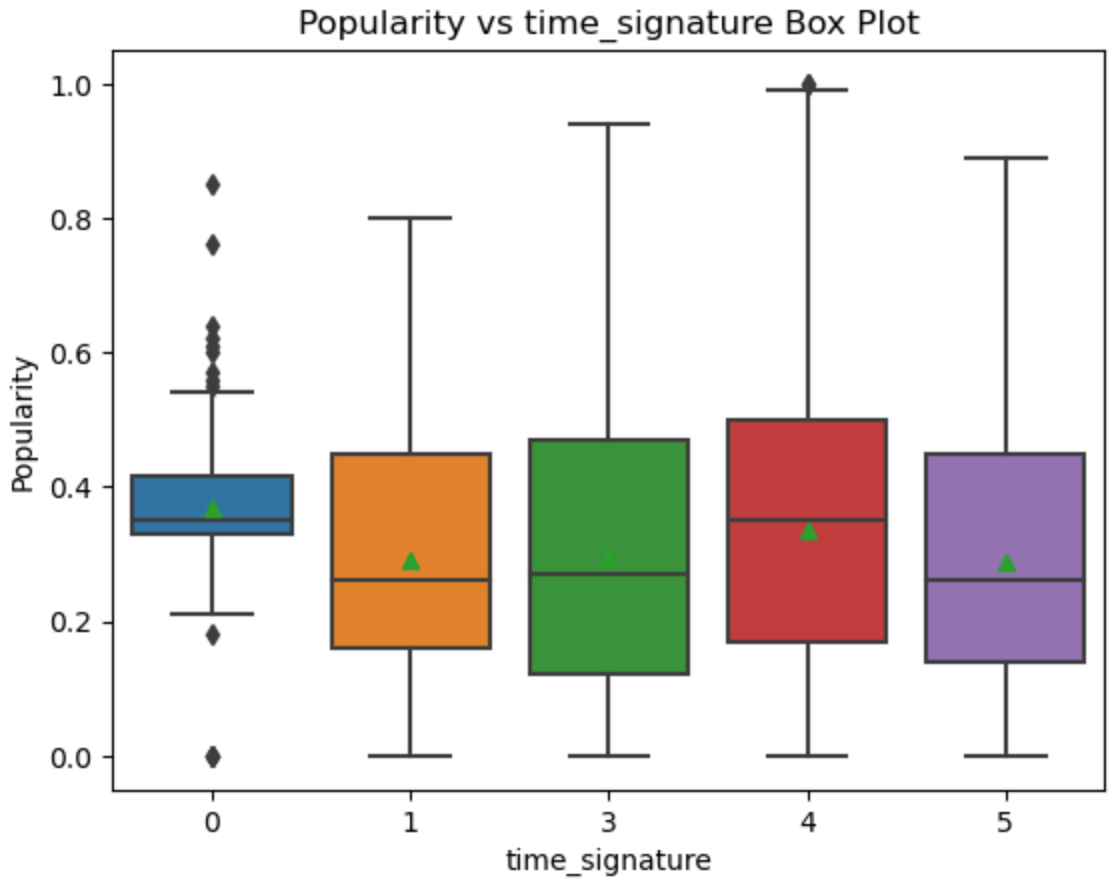
In [144…
```
spotify['explicit']
```

Out[144]:
```
0         0.329379
1         0.329379
2         0.329379
3         0.329379
4         0.329379
            ...
113995    0.329379
113996    0.329379
113997    0.329379
113998    0.329379
113999    0.329379
Name: explicit, Length: 114000, dtype: float64
```

In [145…
```
sns.boxplot(
    x = 'time_signature',
    y = 'popularity',
    showmeans=True,
    data=spotify
)
```

```
plt.title('Popularity vs time_signature Box Plot')
plt.xlabel('time_signature')
plt.ylabel('Popularity')

plt.show()
```



In [146…
```
mean_popularity_by_time_signature = spotify.groupby('time_signature')['popularity'].mean

print(mean_popularity_by_time_signature)
```

```
time_signature
0    0.369755
1    0.290740
3    0.296924
4    0.336725
5    0.287782
Name: popularity, dtype: float64
```

In [147…
```
time_signature_to_popularity_mean_mapping = dict(zip(mean_popularity_by_time_signature.i
spotify['time_signature'] = spotify['time_signature'].replace(time_signature_to_populari
```

In [148…
```
spotify['time_signature']
```

Out[148]:
```
0         0.336725
1         0.336725
2         0.336725
3         0.296924
4         0.336725
             ...
113995    0.287782
113996    0.336725
113997    0.336725
113998    0.336725
113999    0.336725
Name: time_signature, Length: 114000, dtype: float64
```

In [149…
```
spotify.head()
```

Out[149]:

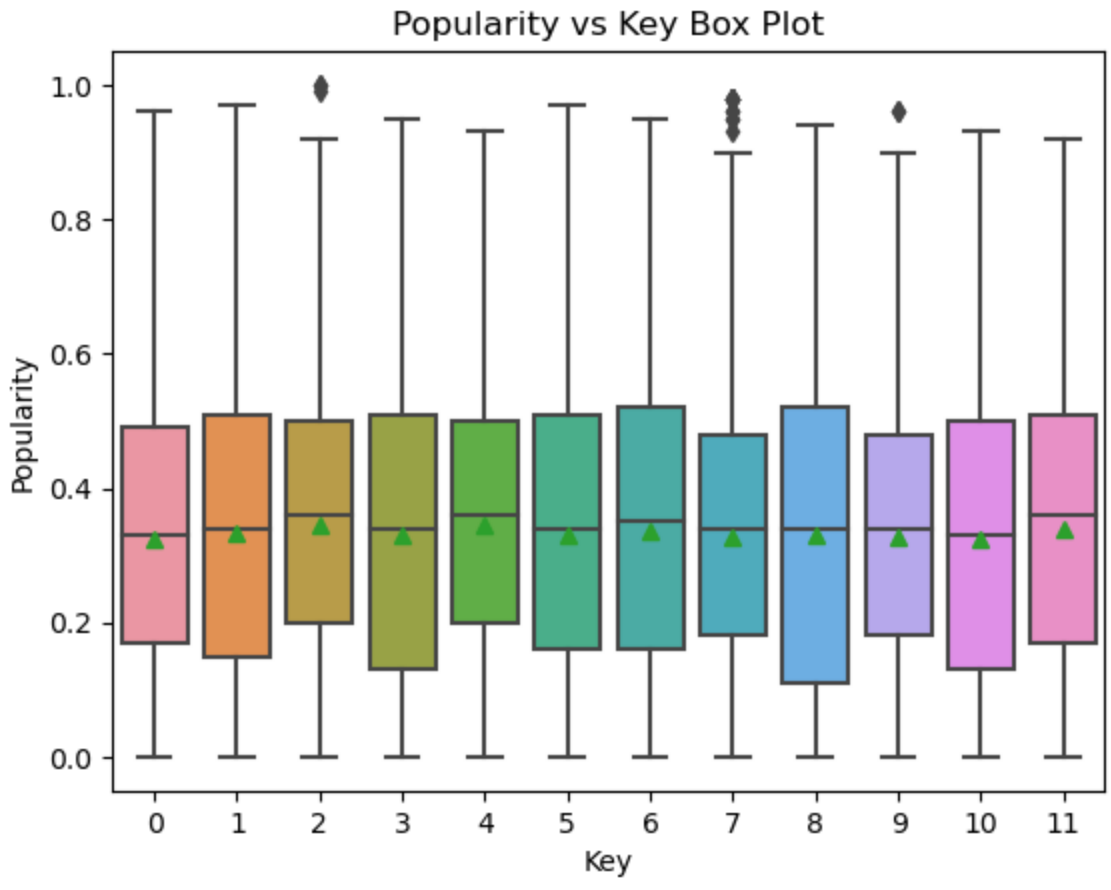
	Unnamed: 0	track_id	artists	album_name	track_name	popularity	duration_ms	ex
0	0	5SuOikwiRyPMVoIQDJUgSV	Gen Hoshino	Comedy	Comedy	0.73	0.044043	0.32
1	1	4qPNDBW1i3p13qLCt0Ki3A	Ben Woodward	Ghost (Acoustic)	Ghost - Acoustic	0.55	0.028566	0.32
2	2	1iJBSr7s7jYXzM8EGcbK5b	Ingrid Michaelson;ZAYN	To Begin Again	To Begin Again	0.57	0.040255	0.32
3	3	6lfxq3CG4xtTiEg7opyCyx	Kina Grannis	Crazy Rich Asians (Original Motion Picture Sou...	Can't Help Falling In Love	0.71	0.038557	0.32
4	4	5vjLSffimiIP26QG5WcN2K	Chord Overstreet	Hold On	Hold On	0.82	0.037969	0.32

5 rows × 21 columns

In [150…
```
sns.boxplot(
    x = 'key',
    y = 'popularity',
    showmeans=True,
    data=spotify
)

plt.title('Popularity vs Key Box Plot')
plt.xlabel('Key')
plt.ylabel('Popularity')

plt.show()
```



In [151…
```
import pandas as pd

mean_popularity_by_key = spotify.groupby('key')['popularity'].mean()

print(mean_popularity_by_key)
```

```
key
0     0.325199
1     0.332002
2     0.343776
3     0.330317
4     0.346437
5     0.329309
6     0.335855
7     0.325796
8     0.329587
9     0.328236
10    0.324614
11    0.338876
Name: popularity, dtype: float64
```

In [152…
```
import pandas as pd

mean_popularity_by_genre = spotify.groupby('track_genre')['popularity'].mean()

print(mean_popularity_by_genre)
```

```
track_genre
acoustic       0.42483
afrobeat       0.24399
alt-rock       0.33943
alternative    0.24337
ambient        0.44191
                ...
techno         0.39042
trance         0.37635
trip-hop       0.34460
turkish        0.40698
world-music    0.41873
Name: popularity, Length: 114, dtype: float64
```

In [153…
```
a = spotify['track_genre'].unique()
```

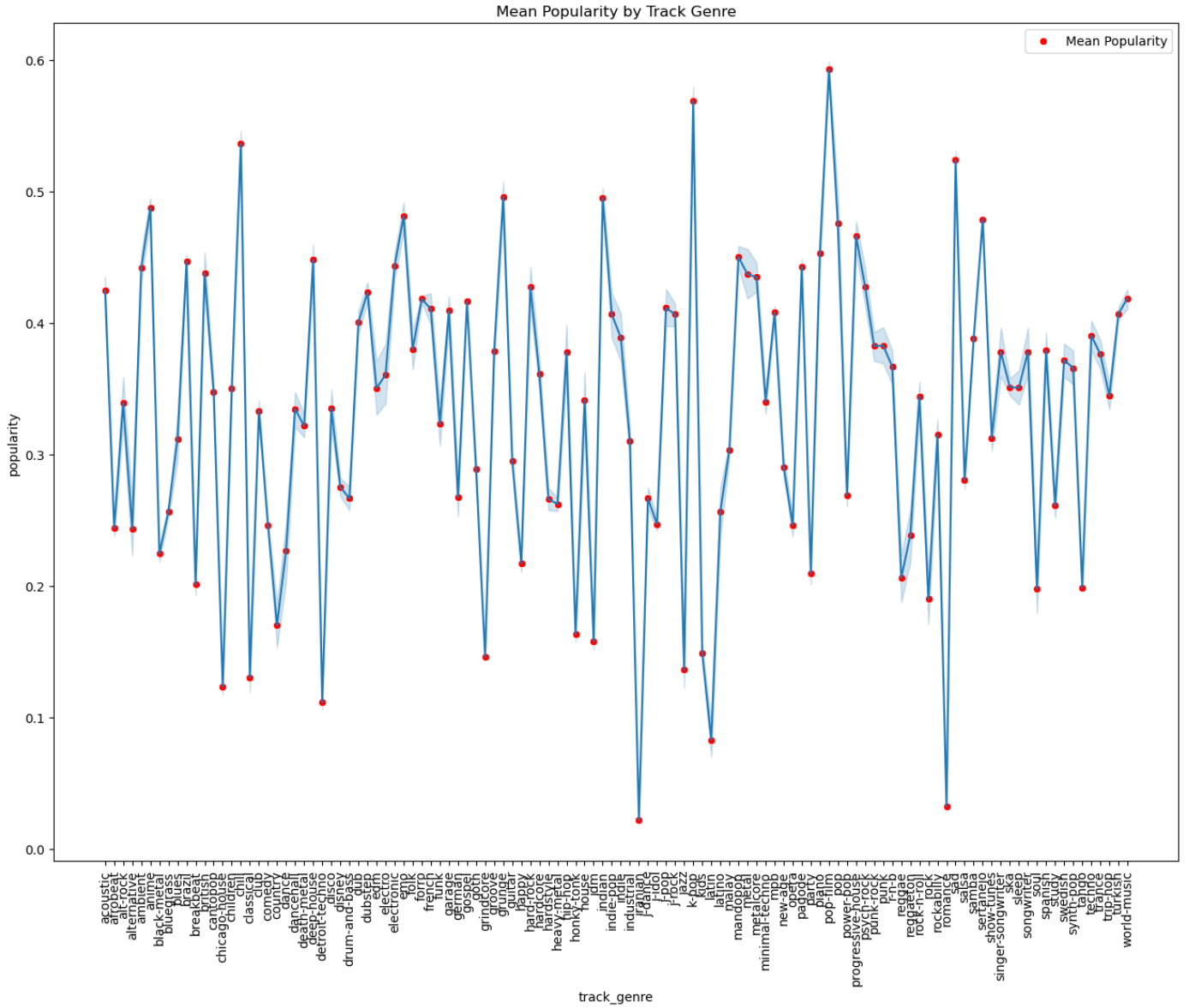
In [154…
```
print(a)
```

```
['acoustic' 'afrobeat' 'alt-rock' 'alternative' 'ambient' 'anime'
 'black-metal' 'bluegrass' 'blues' 'brazil' 'breakbeat' 'british'
 'cantopop' 'chicago-house' 'children' 'chill' 'classical' 'club' 'comedy'
 'country' 'dance' 'dancehall' 'death-metal' 'deep-house' 'detroit-techno'
 'disco' 'disney' 'drum-and-bass' 'dub' 'dubstep' 'edm' 'electro'
 'electronic' 'emo' 'folk' 'forro' 'french' 'funk' 'garage' 'german'
 'gospel' 'goth' 'grindcore' 'groove' 'grunge' 'guitar' 'happy'
 'hard-rock' 'hardcore' 'hardstyle' 'heavy-metal' 'hip-hop' 'honky-tonk'
 'house' 'idm' 'indian' 'indie-pop' 'indie' 'industrial' 'iranian'
 'j-dance' 'j-idol' 'j-pop' 'j-rock' 'jazz' 'k-pop' 'kids' 'latin'
 'latino' 'malay' 'mandopop' 'metal' 'metalcore' 'minimal-techno' 'mpb'
 'new-age' 'opera' 'pagode' 'party' 'piano' 'pop-film' 'pop' 'power-pop'
 'progressive-house' 'psych-rock' 'punk-rock' 'punk' 'r-n-b' 'reggae'
 'reggaeton' 'rock-n-roll' 'rock' 'rockabilly' 'romance' 'sad' 'salsa'
 'samba' 'sertanejo' 'show-tunes' 'singer-songwriter' 'ska' 'sleep'
 'songwriter' 'soul' 'spanish' 'study' 'swedish' 'synth-pop' 'tango'
 'techno' 'trance' 'trip-hop' 'turkish' 'world-music']
```

In [161…
```
mean_popularity_by_track_genre = spotify.groupby('track_genre')['popularity'].mean()
```

```
mean_popularity_df = pd.DataFrame({'track_genre': mean_popularity_by_track_genre.index,

plt.figure(figsize=(16,12))
sns.lineplot(x='track_genre', y='popularity', data=spotify)
sns.scatterplot(x='track_genre', y='popularity', data=mean_popularity_df, label='Mean Po
plt.xticks(rotation=90)
plt.title('Mean Popularity by Track Genre')
plt.legend()
plt.show()
```



In [162…
```
mean_popularity_by_genre.describe()
```

Out[162]:
```
count    114.000000
mean       0.332385
std        0.112948
min        0.022100
25%        0.257840
50%        0.348855
75%        0.411240
max        0.592830
Name: popularity, dtype: float64
```

In [163…
```
genre_to_popularity_mean_mapping = dict(zip(mean_popularity_by_genre.index, mean_popular
```

In [164…
```
spotify['track_genre'] = spotify['track_genre'].replace(genre_to_popularity_mean_mapping
```

In [165…
```
spotify['track_genre']
```

Out[165]:
```
0         0.42483
1         0.42483
2         0.42483
3         0.42483
4         0.42483
           ...
113995    0.41873
113996    0.41873
113997    0.41873
113998    0.41873
113999    0.41873
Name: track_genre, Length: 114000, dtype: float64
```

In [166…
```
spotify.head()
```

Out[166]:

	Unnamed: 0	track_id	artists	album_name	track_name	popularity	duration_ms	ex
0	0	5SuOikwiRyPMVoIQDJUgSV	Gen Hoshino	Comedy	Comedy	0.73	0.044043	0.32
1	1	4qPNDBW1i3p13qLCt0Ki3A	Ben Woodward	Ghost (Acoustic)	Ghost - Acoustic	0.55	0.028566	0.32
2	2	1iJBSr7s7jYXzM8EGcbK5b	Ingrid Michaelson;ZAYN	To Begin Again	To Begin Again	0.57	0.040255	0.32
3	3	6lfxq3CG4xtTiEg7opyCyx	Kina Grannis	Crazy Rich Asians (Original Motion Picture Sou...	Can't Help Falling In Love	0.71	0.038557	0.32
4	4	5vjLSffimiIP26QG5WcN2K	Chord Overstreet	Hold On	Hold On	0.82	0.037969	0.32

5 rows × 21 columns

In [167…
```
target_feature
```

Out[167]:
```
'popularity'
```

In [168…
```
import pandas as pd
import numpy as np

#Normalizationv
categorical_features = ['track_genre', 'explicit', 'time_signature']  # Replace these wi



# Converting into 64 bit
spotify[categorical_features] = spotify[categorical_features].astype('float64')


# Gradient clipping (thershold = 0.5)
spotify[categorical_features] = np.clip(spotify[categorical_features], 0, 0.5)

combined = ['track_genre', 'explicit', 'time_signature','duration_ms', 'danceability', '
combined_for_corr = ['popularity','track_genre', 'explicit', 'time_signature','duration_
```

In [169…
```
combined
```

Out[169]:
```
['track_genre',
 'explicit',
 'time_signature',
 'duration_ms',
```

```
'danceability',
'energy',
'speechiness',
'acousticness',
'instrumentalness',
'liveness',
'valence',
'tempo']
```

In [170…
```
spotify[combined]
```

Out[170]:

	track_genre	explicit	time_signature	duration_ms	danceability	energy	speechiness	acousticness	inst
0	0.42483	0.329379	0.336725	0.044043	0.500000	0.4610	0.148187	0.032329	
1	0.42483	0.329379	0.336725	0.028566	0.426396	0.1660	0.079067	0.500000	
2	0.42483	0.329379	0.336725	0.040255	0.444670	0.3590	0.057720	0.210843	
3	0.42483	0.329379	0.296924	0.038557	0.270051	0.0596	0.037617	0.500000	
4	0.42483	0.329379	0.336725	0.037969	0.500000	0.4430	0.054508	0.470884	
...	...	...	...	...	...	...	...	...	
113995	0.41873	0.329379	0.287782	0.073511	0.174619	0.2350	0.043731	0.500000	
113996	0.41873	0.329379	0.336725	0.073511	0.176650	0.1170	0.041554	0.500000	
113997	0.41873	0.329379	0.336725	0.051833	0.500000	0.3290	0.043523	0.500000	
113998	0.41873	0.329379	0.336725	0.054206	0.500000	0.5000	0.030777	0.382530	
113999	0.41873	0.329379	0.336725	0.046174	0.500000	0.4870	0.075130	0.500000	

114000 rows × 12 columns

In [171…
```
dataset=spotify.copy()
plt.figure(figsize=(10,6))
sns.heatmap(spotify[combined_for_corr].corr(), annot=True)
plt.show()
```

In [172…
```
spotify[target_feature]
```

Out[172]:
```
0          0.73
1          0.55
2          0.57
3          0.71
4          0.82
           ...
113995     0.21
113996     0.22
113997     0.22
113998     0.41
113999     0.22
Name: popularity, Length: 114000, dtype: float64
```

In [173…
```
X_combined = spotify[combined].values
y = spotify[target_feature].values
```

In [174…
```
alpha = 0.1
learning_rate = 0.1
num_iterations = 1000

# applying the algortihm
avg_mse, avg_mae = k_fold_cross_validation(X_combined, y, alpha, learning_rate, num_iter

print("Mean squared error:", avg_mse)
print("Mean absolute error:", avg_mae)
```

```
Mean squared error: 0.037387965102165 81
Mean absolute error: 0.14498254711290487
```