DataAnaCW

April 26, 2024

1 Importing all modules

[20]:
```
import sklearn
import numpy as np
import random
import csv
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
import spotipy #if doesn't work run "pip install spotipy" in terminal

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, r2_score
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import GradientBoostingRegressor
from catboost import CatBoostRegressor #if doesn't work run "pip install␣
 ↪catboost" in terminal
from sklearn.model_selection import cross_val_score

import shap #if doesn't work run "pip install shap" in terminal
```

2 Data Collection from API

[3]:
```
#check that Spotipy Library works
try:
    import spotipy
    print("spotipy imported successfuclly!")
except ImportError:
    print("spotipy failed to import:", ImportError)

#using my API code to get access to API
```

```
from spotipy.oauth2 import SpotifyClientCredentials
client_credentials_manager =␣
 ↪SpotifyClientCredentials(client_id='b5bc39e6f468445a96b07b93f3c30bd6',␣
 ↪client_secret='8363f83f5fe1427eb52c635356e34161')
sp = spotipy.Spotify(client_credentials_manager=client_credentials_manager)

#Function: Fetches tracks from playlists to list
def fetch_tracks_from_playlists(playlist_ids):
    track_ids = []
    for playlist_id in playlist_ids:
        response = sp.playlist_items(playlist_id)
        while response:
            tracks = response['items']
            for item in tracks:
                track = item['track']
                if track:
                    track_ids.append(track['id'])
            if response['next']:
                response = sp.next(response)
            else:
                response = None
    return track_ids

#Using track ID's obtained creates CSV with audio features from API
def write_audio_features_and_followers_to_csv(track_ids,␣
 ↪file_name='spotify_audio_features_v4.csv'):
    with open(file_name, mode='w', newline='', encoding='utf-8') as file:
        writer = csv.writer(file)
        writer.writerow(['track_id', 'popularity', 'acousticness',␣
 ↪'danceability', 'energy', 'instrumentalness',
                         'key', 'liveness', 'loudness', 'mode', 'speechiness',␣
 ↪'tempo', 'time_signature',
                         'valence', 'artist_followers'])

        for track_id in track_ids:
            features = sp.audio_features([track_id])[0]
            track_info = sp.track(track_id)

            if features and track_info:
                primary_artist_id = track_info['artists'][0]['id']
                artist_info = sp.artist(primary_artist_id)
                artist_followers = artist_info['followers']['total']

                writer.writerow([
                    track_id,
                    track_info['popularity'],
                    features['acousticness'],
```

```
                    features['danceability'],
                    features['energy'],
                    features['instrumentalness'],
                    features['key'],
                    features['liveness'],
                    features['loudness'],
                    features['mode'],
                    features['speechiness'],
                    features['tempo'],
                    features['time_signature'],
                    features['valence'],
                    artist_followers
                ])

#Using functions to retrieve tracks from following playlist ID's and obtain␣
 ↪audio features
#This has been commented out so i'm not constantly maxing out my API!

# playlist_ids = ['4tsFVEcLmtDi23y735cO7F',␣
 ↪'37i9dQZF1DWWjGdmeTyeJ6','37i9dQZF1EIXKVeX9Tn4oI','6nKgvpnVm71pmTb4kjXRWE','5ComKFYBvZW31sB
 ↪ # Replace with actual playlist IDs
# track_ids = fetch_tracks_from_playlists(playlist_ids)
# write_audio_features_and_followers_to_csv(track_ids)
```

spotipy imported successfuclly!

Max Retries reached

```
---------------------------------------------------------------------------
ResponseError                             Traceback (most recent call last)
ResponseError: too many 429 error responses

The above exception was the direct cause of the following exception:

MaxRetryError                             Traceback (most recent call last)
File /opt/conda/lib/python3.10/site-packages/requests/adapters.py:486, in␣
 ↪HTTPAdapter.send(self, request, stream, timeout, verify, cert, proxies)
    485 try:
--> 486     resp = conn.urlopen(
    487         method=request.method,
    488         url=url,
    489         body=request.body,
    490         headers=request.headers,
    491         redirect=False,
    492         assert_same_host=False,
    493         preload_content=False,
    494         decode_content=False,
    495         retries=self.max_retries,
```

```
    496             timeout=timeout,
    497             chunked=chunked,
    498         )
    500 except (ProtocolError, OSError) as err:

File /opt/conda/lib/python3.10/site-packages/urllib3/connectionpool.py:946, in␣
 ↪HTTPConnectionPool.urlopen(self, method, url, body, headers, retries,␣
 ↪redirect, assert_same_host, timeout, pool_timeout, release_conn, chunked,␣
 ↪body_pos, preload_content, decode_content, **response_kw)
    945     log.debug("Retry: %s", url)
--> 946     return self.urlopen(
    947         method,
    948         url,
    949         body,
    950         headers,
    951         retries=retries,
    952         redirect=redirect,
    953         assert_same_host=assert_same_host,
    954         timeout=timeout,
    955         pool_timeout=pool_timeout,
    956         release_conn=release_conn,
    957         chunked=chunked,
    958         body_pos=body_pos,
    959         preload_content=preload_content,
    960         decode_content=decode_content,
    961         **response_kw,
    962     )
    964 return response

File /opt/conda/lib/python3.10/site-packages/urllib3/connectionpool.py:946, in␣
 ↪HTTPConnectionPool.urlopen(self, method, url, body, headers, retries,␣
 ↪redirect, assert_same_host, timeout, pool_timeout, release_conn, chunked,␣
 ↪body_pos, preload_content, decode_content, **response_kw)
    945     log.debug("Retry: %s", url)
--> 946     return self.urlopen(
    947         method,
    948         url,
    949         body,
    950         headers,
    951         retries=retries,
    952         redirect=redirect,
    953         assert_same_host=assert_same_host,
    954         timeout=timeout,
    955         pool_timeout=pool_timeout,
    956         release_conn=release_conn,
    957         chunked=chunked,
    958         body_pos=body_pos,
    959         preload_content=preload_content,
    960         decode_content=decode_content,
```

```
    961             **response_kw,
    962         )
    964 return response

File /opt/conda/lib/python3.10/site-packages/urllib3/connectionpool.py:946, in␣
 ↪HTTPConnectionPool.urlopen(self, method, url, body, headers, retries,␣
 ↪redirect, assert_same_host, timeout, pool_timeout, release_conn, chunked,␣
 ↪body_pos, preload_content, decode_content, **response_kw)
    945     log.debug("Retry: %s", url)
--> 946     return self.urlopen(
    947         method,
    948         url,
    949         body,
    950         headers,
    951         retries=retries,
    952         redirect=redirect,
    953         assert_same_host=assert_same_host,
    954         timeout=timeout,
    955         pool_timeout=pool_timeout,
    956         release_conn=release_conn,
    957         chunked=chunked,
    958         body_pos=body_pos,
    959         preload_content=preload_content,
    960         decode_content=decode_content,
    961         **response_kw,
    962     )
    964 return response

File /opt/conda/lib/python3.10/site-packages/urllib3/connectionpool.py:936, in␣
 ↪HTTPConnectionPool.urlopen(self, method, url, body, headers, retries,␣
 ↪redirect, assert_same_host, timeout, pool_timeout, release_conn, chunked,␣
 ↪body_pos, preload_content, decode_content, **response_kw)
    935 try:
--> 936     retries =␣
 ↪retries.increment(method, url, response=response, _pool=self)
    937 except MaxRetryError:

File /opt/conda/lib/python3.10/site-packages/urllib3/util/retry.py:515, in Retr
 ↪increment(self, method, url, response, error, _pool, _stacktrace)
    514     reason = error or ResponseError(cause)
--> 515     raise MaxRetryError(_pool, url, reason) from reason  # type:␣
 ↪ignore[arg-type]
    517 log.debug("Incremented Retry for (url='%s'): %r", url, new_retry)

MaxRetryError: HTTPSConnectionPool(host='api.spotify.com', port=443): Max␣
 ↪retries exceeded with url: /v1/audio-features/?ids=4NFBspLQb2QNwZOmj13Y2F␣
 ↪(Caused by ResponseError('too many 429 error responses'))

During handling of the above exception, another exception occurred:
```

```
RetryError                                Traceback (most recent call last)
File /opt/conda/lib/python3.10/site-packages/spotipy/client.py:266, in Spotify.
 ↪_internal_call(self, method, url, payload, params)
    265 try:
--> 266     response = self._session.request(
    267         method, url, headers=headers, proxies=self.proxies,
    268         timeout=self.requests_timeout, **args
    269     )
    271     response.raise_for_status()

File /opt/conda/lib/python3.10/site-packages/requests/sessions.py:589, in␣
 ↪Session.request(self, method, url, params, data, headers, cookies, files,␣
 ↪auth, timeout, allow_redirects, proxies, hooks, stream, verify, cert, json)
    588 send_kwargs.update(settings)
--> 589 resp = self.send(prep, **send_kwargs)
    591 return resp

File /opt/conda/lib/python3.10/site-packages/requests/sessions.py:703, in␣
 ↪Session.send(self, request, **kwargs)
    702 # Send the request
--> 703 r = adapter.send(request, **kwargs)
    705 # Total elapsed time of the request (approximately)

File /opt/conda/lib/python3.10/site-packages/requests/adapters.py:510, in␣
 ↪HTTPAdapter.send(self, request, stream, timeout, verify, cert, proxies)
    509 if isinstance(e.reason, ResponseError):
--> 510     raise RetryError(e, request=request)
    512 if isinstance(e.reason, _ProxyError):

RetryError: HTTPSConnectionPool(host='api.spotify.com', port=443): Max retries␣
 ↪exceeded with url: /v1/audio-features/?ids=4NFBspLQb2QNwZOmj13Y2F (Caused by␣
 ↪ResponseError('too many 429 error responses'))

During handling of the above exception, another exception occurred:

SpotifyException                          Traceback (most recent call last)
Cell In[3], line 68
     66 playlist_ids = ['4tsFVEcLmtDi23y735cO7F',␣
 ↪'37i9dQZF1DWWjGdmeTyeJ6','37i9dQZF1EIXKVeX9Tn4oI','6nKgvpnVm71pmTb4kjXRWE','5 omKFYBvZW31sI
 ↪ # Replace with actual playlist IDs
     67 track_ids = fetch_tracks_from_playlists(playlist_ids)
---> 68 write_audio_features_and_followers_to_csv(track_ids)

Cell In[3], line 39, in write_audio_features_and_followers_to_csv(track_ids,␣
 ↪file_name)
     34 writer.writerow(['track_id', 'popularity', 'acousticness',␣
 ↪'danceability', 'energy', 'instrumentalness',
```

```
     35                  'key', 'liveness', 'loudness', 'mode', 'speechiness',␣
 ↪'tempo', 'time_signature',
     36                  'valence', 'artist_followers'])
     38 for track_id in track_ids:
---> 39     features = sp.audio_features([track_id])[0]
     40     track_info = sp.track(track_id)
     42     if features and track_info:

File /opt/conda/lib/python3.10/site-packages/spotipy/client.py:1737, in Spotify
 ↪audio_features(self, tracks)
   1735 else:
   1736     tlist = [self._get_id("track", t) for t in tracks]
-> 1737     results = self._get("audio-features/?ids=" + ",".join(tlist))
   1738 # the response has changed, look for the new style first, and if
   1739 # its not there, fallback on the old style
   1740 if "audio_features" in results:

File /opt/conda/lib/python3.10/site-packages/spotipy/client.py:323, in Spotify.
 ↪_get(self, url, args, payload, **kwargs)
    320 if args:
    321     kwargs.update(args)
--> 323 return self._internal_call("GET", url, payload, kwargs)

File /opt/conda/lib/python3.10/site-packages/spotipy/client.py:307, in Spotify.
 ↪_internal_call(self, method, url, payload, params)
    305     except (IndexError, AttributeError):
    306         reason = None
--> 307     raise SpotifyException(
    308         429,
    309         -1,
    310         "%s:\n %s" % (request.path_url, "Max Retries"),
    311         reason=reason
    312     )
    313 except ValueError:
    314     results = None

SpotifyException: http status: 429, code:-1 - /v1/audio-features/?
 ↪ids=4NFBspLQb2QNwZOmj13Y2F:
 Max Retries, reason: too many 429 error responses
```

3 Pre-Model Imaging (Graphs) and Data Cleaning

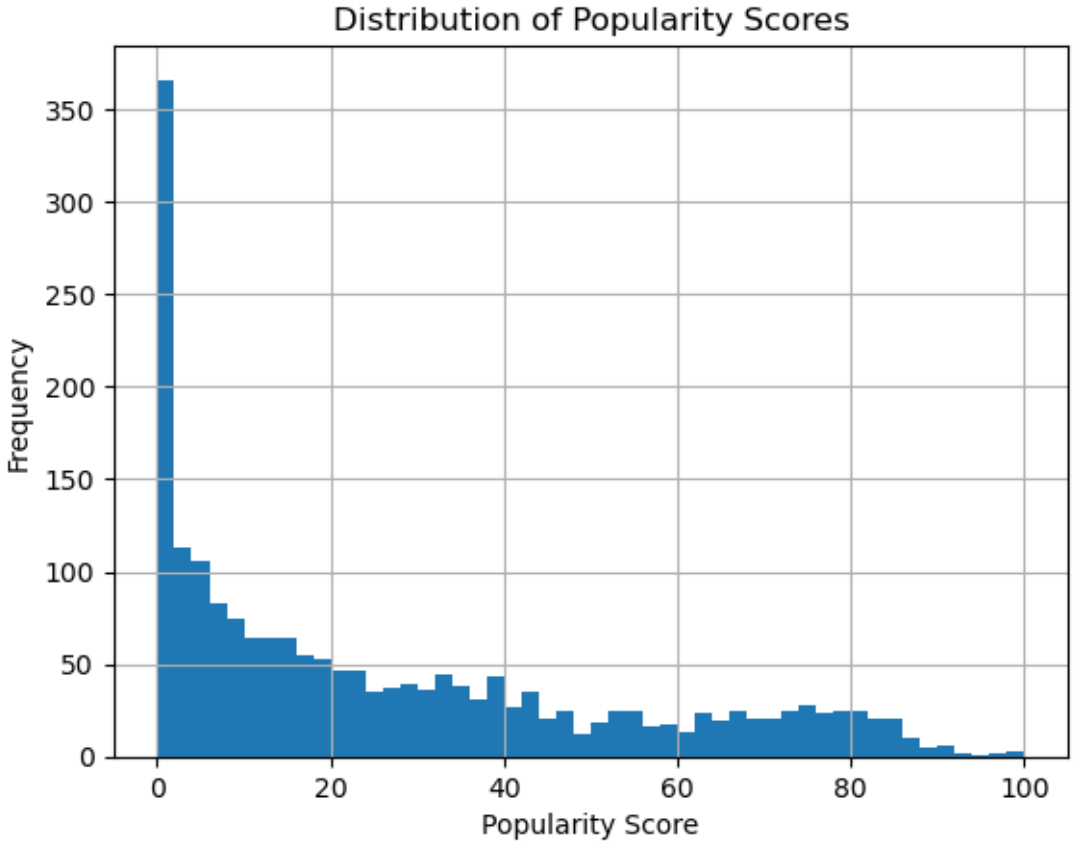
[7]:
```
#replace with where the data may be held:
#df = pd.read_csv(r"C:\Users\jadcr\spotify_audio_features_v4.csv")
df = pd.read_csv("spotify_audio_features_v4.csv")
```

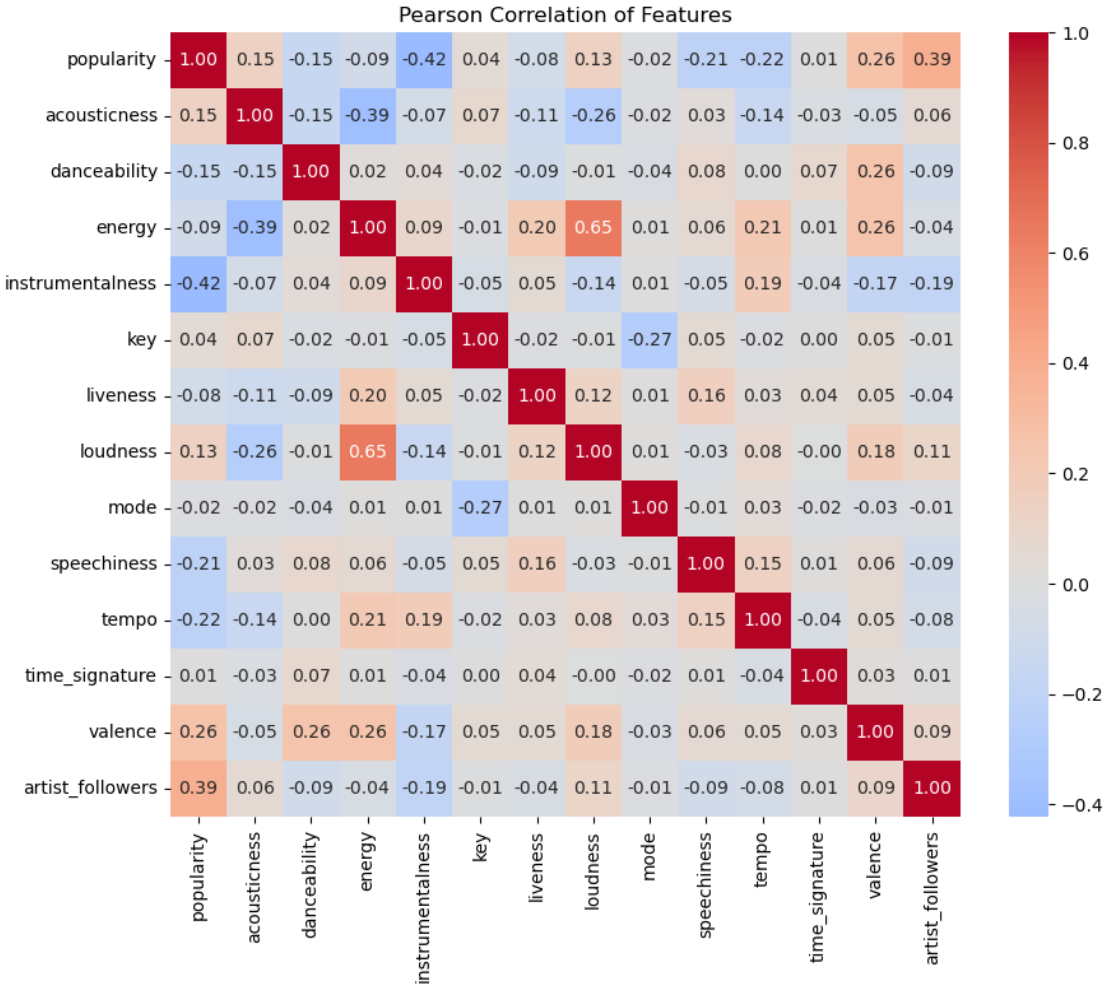
```
# try:
#     df = pd.read_csv("spotify_audio_features_v4.csv")
#     print("Read the CSV")
# except Exception as e:  # This catches any exception and stores it in␣
 ↪variable e
#     print("Failed to read the CSV:", e)

#Typical bad data handling and describing:
print(df.head())
df = df.drop_duplicates()
df = df.dropna()
#Prints if data is unclean (empty rowws etc):
print(df.isnull().sum())
print(df.describe())

#Histogram of Popularity score distribution
df['popularity'].hist(bins=50)
plt.title('Distribution of Popularity Scores')
plt.xlabel('Popularity Score')
plt.ylabel('Frequency')
plt.show()

# Creating the heatmap using seaborn
df = df.drop(['track_id'], axis=1)
correlation_matrix = df.corr()
plt.figure(figsize=(10, 8))
sns.heatmap(correlation_matrix, annot=True, fmt='.2f', cmap='coolwarm',␣
 ↪center=0)
plt.title('Pearson Correlation of Features')
plt.show()
```

```
                track_id  popularity  acousticness  danceability  energy  \
0  3Fzlg5r1IjhLk2qRw667od          81       0.06240         0.632   0.856
1  1q9l6c8bAzqWcvO3DM6FsR          65       0.01950         0.707   0.923
2  4356Typ82hUiFAynbLYbPn          86       0.03380         0.663   0.861
3  003vvx7Niy0yvhvHt4a68B          90       0.00121         0.352   0.911
4  2PpruBYCo4H7WOBJ7Q2EwM          85       0.10300         0.727   0.974

   instrumentalness  key  liveness  loudness  mode  speechiness    tempo  \
0          0.000000   10    0.3470    -3.463     1       0.0348  119.397
1          0.000000    7    0.3420    -3.409     1       0.0276  108.023
2          0.000000    7    0.0820    -3.398     0       0.1090  119.963
3          0.000000    1    0.0995    -5.230     1       0.0747  148.033
4          0.000532    4    0.1740    -2.261     0       0.0664   79.526

   time_signature  valence  artist_followers
0               4    0.867             85824
```

```
1                4    0.845            531596
2                4    0.654          10917316
3                4    0.236           7143657
4                4    0.965           2506825
track_id             0
popularity           0
acousticness         0
danceability         0
energy               0
instrumentalness     0
key                  0
liveness             0
loudness             0
mode                 0
speechiness          0
tempo                0
time_signature       0
valence              0
artist_followers     0
dtype: int64
        popularity  acousticness  danceability       energy  instrumentalness  \
count  1980.000000   1980.000000   1980.000000  1980.000000       1980.000000
mean     26.488889      0.156458      0.693334     0.676107          0.360860
std      26.261048      0.216319      0.134257     0.179118          0.381435
min       0.000000      0.000003      0.165000     0.065800          0.000000
25%       4.000000      0.009607      0.621750     0.553000          0.000084
50%      17.500000      0.056450      0.711000     0.688000          0.162500
75%      43.000000      0.207000      0.786000     0.818000          0.796500
max     100.000000      0.973000      0.988000     0.998000          0.976000

               key     liveness     loudness         mode  speechiness  \
count  1980.000000  1980.000000  1980.000000  1980.000000  1980.000000
mean      5.233333     0.196816    -7.924448     0.624747     0.121141
std       3.770326     0.157547     3.275912     0.484310     0.113455
min       0.000000     0.016500   -20.466000     0.000000     0.023400
25%       1.000000     0.100000   -10.010500     0.000000     0.044700
50%       5.000000     0.127000    -7.724000     1.000000     0.070350
75%       9.000000     0.256500    -5.720000     1.000000     0.163000
max      11.000000     0.961000     1.646000     1.000000     0.807000

             tempo  time_signature      valence  artist_followers
count  1980.000000     1980.000000  1980.000000      1.980000e+03
mean    131.381855        3.952020     0.441125      1.746819e+06
std      27.773167        0.377782     0.245271      7.930624e+06
min      38.626000        1.000000     0.031800      5.000000e+00
25%     114.664750        4.000000     0.231500      4.294000e+03
50%     132.049000        4.000000     0.422000      1.106200e+04
75%     150.096250        4.000000     0.636250      1.305700e+05
```

```
max       219.881000          5.000000       0.978000       1.129142e+08
```



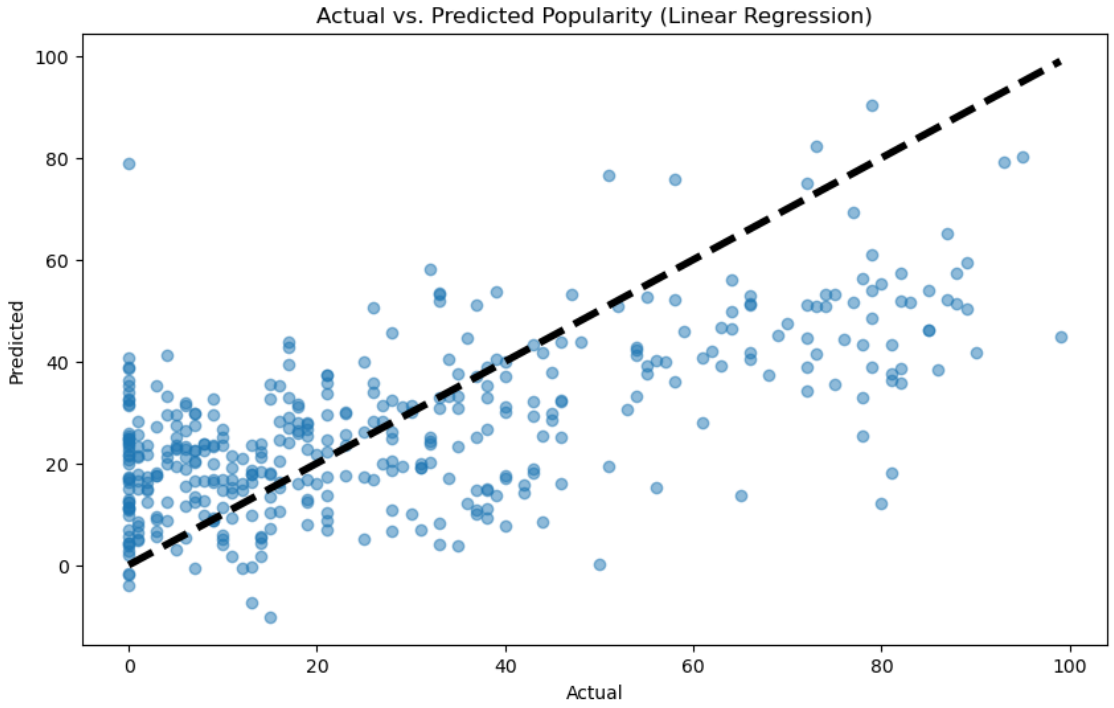


4 Linear Regression Model

[10]:
```
df = pd.read_csv("spotify_audio_features_v4.csv")

#Ensuring Target Variables defined
X = df.drop(['popularity', 'track_id'], axis=1)
y = df['popularity']
#in the evaluation of my paper I compare results with dropping initial artist␣
 ↪followers
#if you wish to test the data in the same way, replace line 4 with: X = df.
 ↪drop(['popularity', 'track_id','artist_followers'], axis=1)  # Adjust␣
 ↪'track_id' as per your DataFrame as standardisation doesnt work with␣
 ↪non-numerical values

#Splitting Data set
```

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

#Scaler for data normalisation prior to model creation
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
lin_reg = LinearRegression()
lin_reg.fit(X_train_scaled, y_train)
y_pred_lin = lin_reg.predict(X_test_scaled)

# Evaluating the model
mse_lin = mean_squared_error(y_test, y_pred_lin)
r2_lin = r2_score(y_test, y_pred_lin)

print(f"Linear Regression MSE: {mse_lin}")
print(f"Linear Regression R^2: {r2_lin}")

#Function to make graphs to visualise models
def plot_actual_vs_predicted(y_actual, y_predicted, title):
    plt.figure(figsize=(10, 6))
    plt.scatter(y_actual, y_predicted, alpha=0.5)
    plt.plot([y_actual.min(), y_actual.max()], [y_actual.min(), y_actual.
 ↪max()], 'k--', lw=4)  # Diagonal line
    plt.xlabel('Actual')
    plt.ylabel('Predicted')
    plt.title(title)
    plt.show()

plot_actual_vs_predicted(y_test, y_pred_lin, 'Actual vs. Predicted Popularity␣
 ↪(Linear Regression)')
```

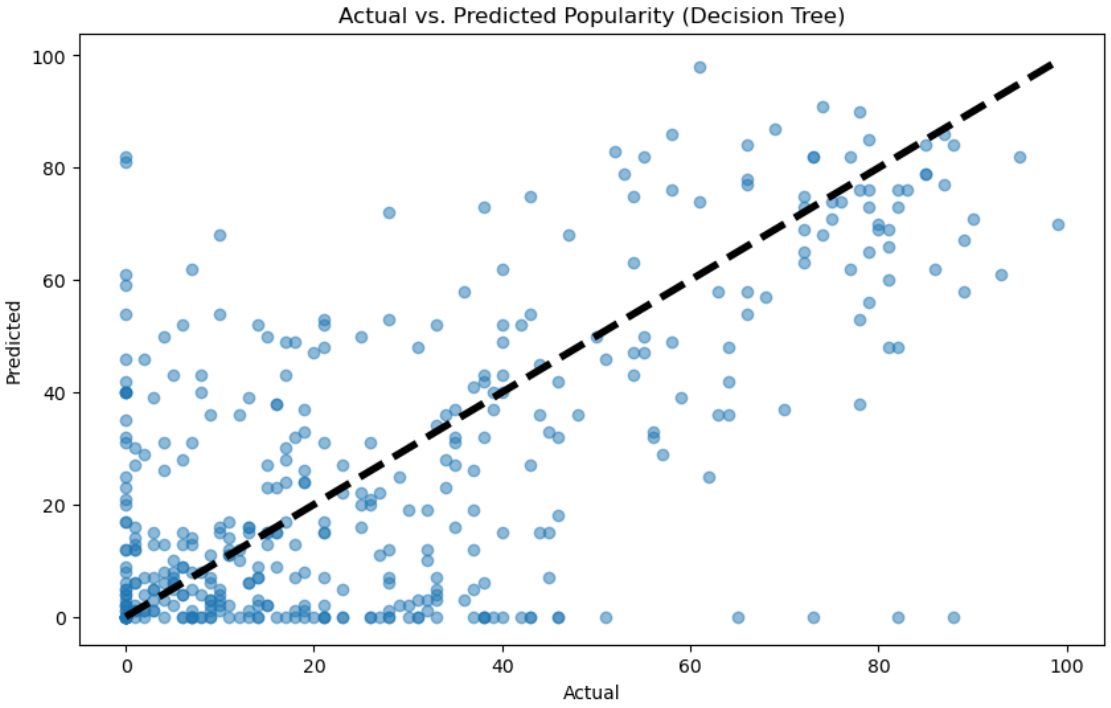
```
Linear Regression MSE: 409.29614991947074
Linear Regression R^2: 0.4140670823833418
```



5 Decision Tree Regression Model

[12]:
```
tree_reg = DecisionTreeRegressor(random_state=42)
tree_reg.fit(X_train_scaled, y_train)

# Predicting on the test set
y_pred_tree = tree_reg.predict(X_test_scaled)

# Evaluating the model
mse_tree = mean_squared_error(y_test, y_pred_tree)
r2_tree = r2_score(y_test, y_pred_tree)

print(f"Decision Tree Regression MSE: {mse_tree}")
print(f"Decision Tree Regression R^2: {r2_tree}")

#Recalling function from before to visualise model
plot_actual_vs_predicted(y_test, y_pred_tree, 'Actual vs. Predicted Popularity␣
↪(Decision Tree)')
```

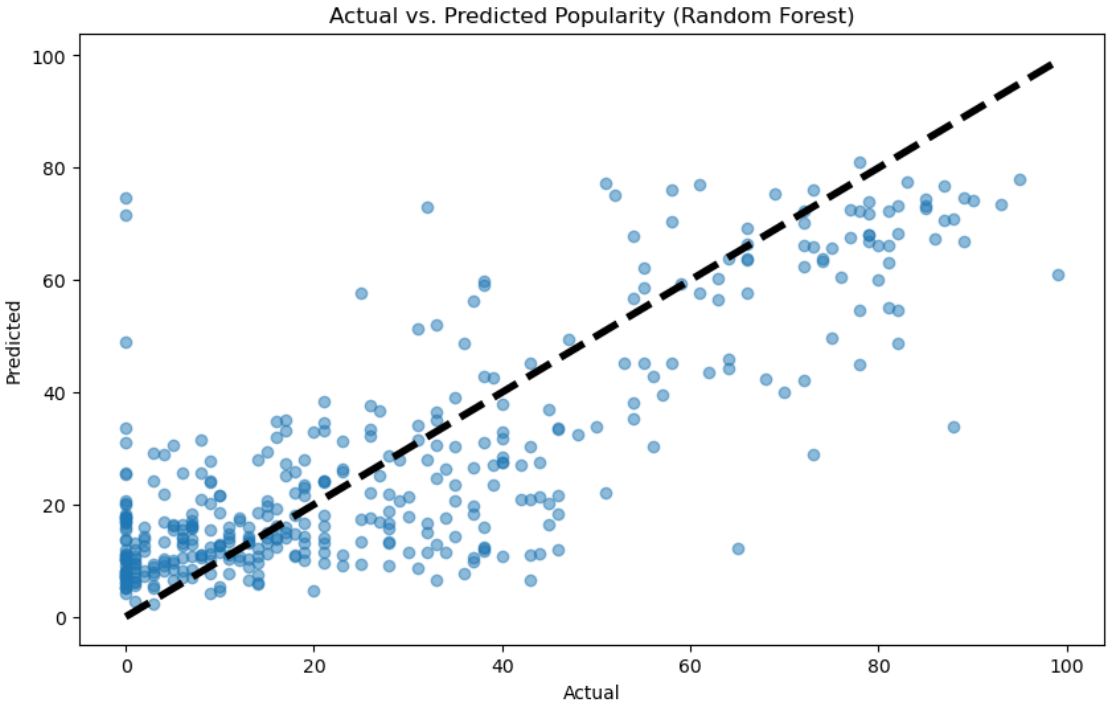
```
Decision Tree Regression MSE: 489.5062344139651
Decision Tree Regression R^2: 0.2992413532886884
```



6 Random Forest Model

[16]:
```
# Initialising/Fitting model standard set-up
rf_reg = RandomForestRegressor(n_estimators=100, random_state=42)  # You can␣
 ↪tune n_estimators and other hyperparameters
rf_reg.fit(X_train_scaled, y_train)
y_pred_rf = rf_reg.predict(X_test_scaled)

# Evaluating the model
mse_rf = mean_squared_error(y_test, y_pred_rf)
r2_rf = r2_score(y_test, y_pred_rf)

print(f"Random Forest Regression MSE: {mse_rf}")
print(f"Random Forest Regression R^2: {r2_rf}")

# Recalling function to visualize
plot_actual_vs_predicted(y_test, y_pred_rf, 'Actual vs. Predicted Popularity␣
 ↪(Random Forest)')
```

```
Random Forest Regression MSE: 237.36263790523694
Random Forest Regression R^2: 0.6602006078279365
```



7 Random Forest Model Hyperparameter Tuning/Optimisation

[25]:
```
#Defining a parameter grid with realistic computational limitations
param_grid = {
    'n_estimators': [100, 200, 300, 400, 500],
    'max_features': ['sqrt', 'log2'],
    'max_depth': [None, 10, 20, 30, 40, 50],
    'min_samples_split': [2, 5, 10, 20]
}

rf_reg = RandomForestRegressor(random_state=42)

#Using RandomizedSearchCV to use the param_grid to find optimal parameters
rf_random = RandomizedSearchCV(estimator=rf_reg,␣
 ↪param_distributions=param_grid, n_iter=100, cv=5, verbose=0,␣
 ↪random_state=42, n_jobs=-1)

#Re-making model with RandomizedSearchCV's best parameters
rf_random.fit(X_train_scaled, y_train)

print(f"Best parameters: {rf_random.best_params_}")
print(f"Best score: {rf_random.best_score_}")
```

```
best_rf = rf_random.best_estimator_
y_pred_rf = best_rf.predict(X_test_scaled)

mse_rf = mean_squared_error(y_test, y_pred_rf)
r2_rf = r2_score(y_test, y_pred_rf)

print(f"Random Forest Regression MSE with best parameters: {mse_rf}")
print(f"Random Forest Regression R^2 with best parameters: {r2_rf}")
```

```
Best parameters: {'n_estimators': 400, 'min_samples_split': 2, 'max_features':
'log2', 'max_depth': 50}
Best score: 0.6280526454700193
Random Forest Regression MSE with best parameters: 228.25624507870947
Random Forest Regression R^2 with best parameters: 0.6732369760392194
```

8 Testing other ensemble methods (GradientBoost, CatBoost)

[27]:
```
#For Gradient Boosting: (Note that param_grid rules change to RF)

# Define the parameter grid
param_grid_gb = {
    'n_estimators': [100, 200, 300],
    'learning_rate': [0.01, 0.1, 0.2],
    'max_depth': [3, 4, 5],
    'min_samples_split': [2, 4],
    'min_samples_leaf': [1, 2]
}

gb = GradientBoostingRegressor(random_state=42)

# Initialize RandomizedSearchCV
gb_random = RandomizedSearchCV(estimator=gb, param_distributions=param_grid_gb,
                               n_iter=100, cv=5, verbose=0, random_state=42,␣
 ↪n_jobs=-1)
gb_random.fit(X_train, y_train)

# Print the best parameters and best score
print("Best parameters for Gradient Boosting:", gb_random.best_params_)
print("Best score for Gradient Boosting:", gb_random.best_score_)

#For CatBoost: (Note again param_grid rules change to RF)

# Define the parameter grid
param_grid_cb = {
    'iterations': [100, 200, 300],
    'learning_rate': [0.01, 0.1, 0.2],
```

```
    'depth': [4, 6, 8],
    'l2_leaf_reg': [1, 3, 5]
}

cb = CatBoostRegressor(silent=True, random_state=42)

# Initialize RandomizedSearchCV
cb_random = RandomizedSearchCV(estimator=cb, param_distributions=param_grid_cb,
                               n_iter=100, cv=5, verbose=0, random_state=42,␣
 ↪n_jobs=-1)
cb_random.fit(X_train, y_train)

# Print the best parameters and best score
print("Best parameters for CatBoost:", cb_random.best_params_)
print("Best score for CatBoost:", cb_random.best_score_)
```

```
Best parameters for Gradient Boosting: {'n_estimators': 100,
'min_samples_split': 4, 'min_samples_leaf': 2, 'max_depth': 3, 'learning_rate':
0.1}
Best score for Gradient Boosting: 0.6151081395821005

The total space of parameters 81 is smaller than n_iter=100. Running 81
iterations. For exhaustive searches, use GridSearchCV.

Best parameters for CatBoost: {'learning_rate': 0.1, 'l2_leaf_reg': 3,
'iterations': 100, 'depth': 6}
Best score for CatBoost: 0.6298600379768633
```

[ ]:

9 Final Optimisation: Cross Validating Ensemble Methods

[28]:
```
# Models with their tuned parameters
models = {
    'RandomForest': RandomForestRegressor(n_estimators=500,␣
 ↪min_samples_split=5, max_features='sqrt', max_depth=None, random_state=42),
    'GradientBoosting': GradientBoostingRegressor(n_estimators=300,␣
 ↪min_samples_split=4, min_samples_leaf=2, max_depth=5, learning_rate=0.01,␣
 ↪random_state=42),
    'CatBoost': CatBoostRegressor(iterations=100, learning_rate=0.1, depth=4,␣
 ↪l2_leaf_reg=5, silent=True, random_state=42)
}

for name, model in models.items():
    # Compute the cross-validation score
    scores = cross_val_score(model, X, y, cv=5,␣
 ↪scoring='neg_mean_squared_error')
```

```
    # Convert MSE scores to RMSE
    rmse_scores = np.sqrt(-scores)

    print(f"{name}:")
    print(f"  RMSE: {np.mean(rmse_scores):.4f} (+/- {np.std(rmse_scores):.4f})")
```

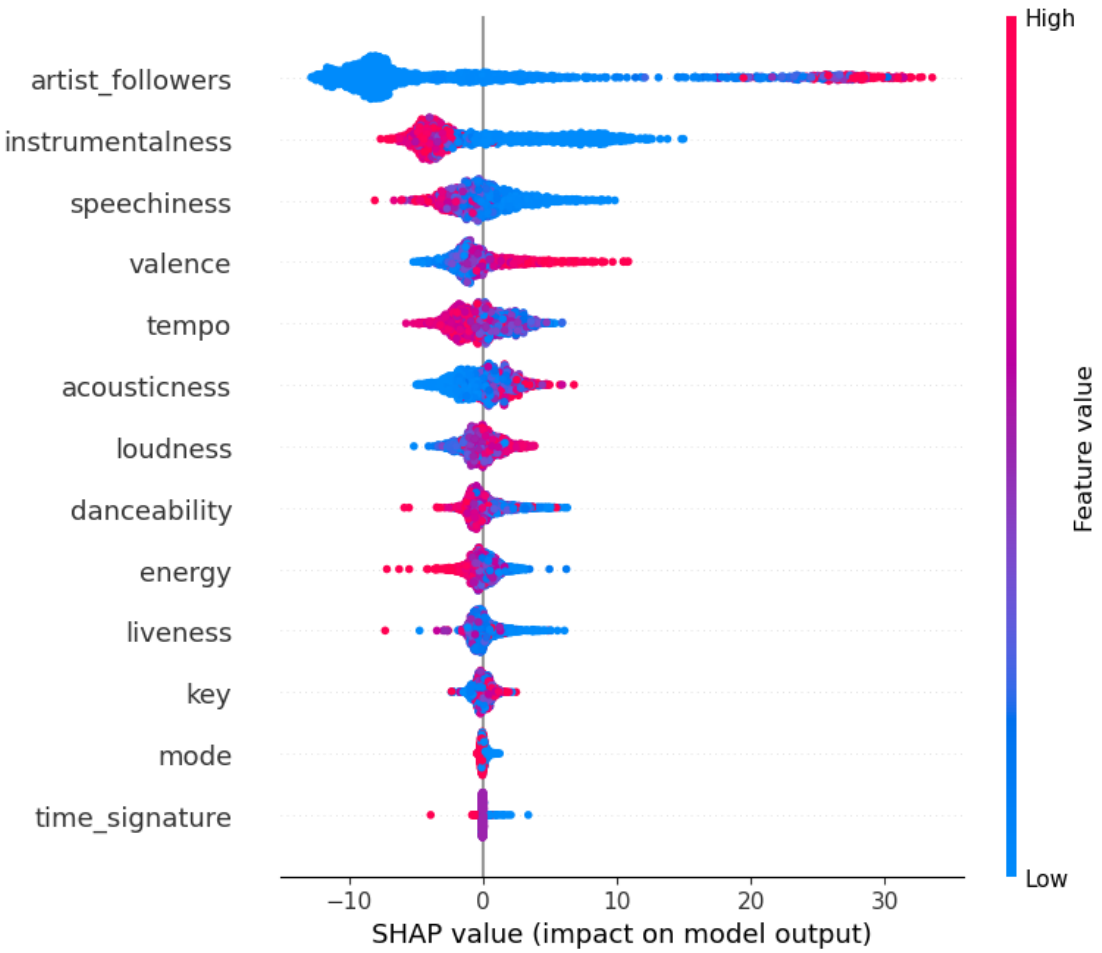
```
RandomForest:
  RMSE: 16.5158 (+/- 3.1381)
GradientBoosting:
  RMSE: 16.9359 (+/- 3.4841)
CatBoost:
  RMSE: 16.9621 (+/- 3.5995)
```

[ ]:

10 SHAP: Feature analysis for evaluative remarks

[23]:
```
feature_names = df.drop(['popularity', 'track_id'], axis=1).columns.tolist()

# Initialize a SHAP explainer
explainer = shap.Explainer(best_rf, X_train_scaled)

# Compute SHAP values for the entire training dataset
shap_values = explainer(X_train_scaled, check_additivity=False)

# Summary plot to visualize feature importances
shap.summary_plot(shap_values, X_train_scaled,feature_names=feature_names)
```

```
100%|==================| 1598/1600 [05:03<00:00]
```


artist_followers
instrumentalness
speechiness
valence
tempo
acousticness
loudness
danceability
energy
liveness
key
mode
time_signature
−10
0
10
20
30
SHAP value (impact on model output)
High
Feature value
Low