Project_4:Music_Popularity_Prediction

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1 Project 4: Music Popularity Prediction

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1.1 Hypothesis:

The popularity of a song on Spotify's Top 200 Weekly (Global) charts in 2020 & 2021 is likely influenced by a combination of audio features, artist popularity, and chart performance metrics. Specifically:

1. Audio Features:
    - Loudness and Energy are likely to be strong predictors of popularity, as more energetic and louder songs tend to perform better on charts.
    - Danceability and Valence (positiveness) may also be important, as upbeat and positive songs often appeal to a wider audience.
    - Tempo could be a factor, with faster-paced songs potentially being more popular in certain genres.
2. Artist Popularity:
    - The number of artist followers is likely to be a significant predictor, as more popular artists tend to have more popular songs.
3. Chart Performance Metrics:
    - Highest Charting Position and Number of Times Charted are likely to be strong indicators of overall popularity.
4. Genre:
    - Certain genres (e.g., pop, hip-hop) may be more represented in the top charts, potentially influencing popularity.
5. Song Characteristics:
    - Duration might play a role, with shorter songs potentially being more popular in recent years.
6. Release Timing:
    - The release date of the song could influence its popularity, with songs released earlier in the year potentially having more time to accumulate popularity.
7. Feature Interactions:
    - The interaction between audio features and artist popularity could be important. For example, a highly energetic song by a popular artist might be more likely to be popular than a similar song by a less known artist.
8. Cultural and Temporal Factors:
    - The dataset spans 2020 & 2021, which includes the COVID-19 pandemic period. This might have influenced listening habits and song popularity.

The data. A chosen data set is provided by DDC Data Science

2 Imports

[79]:
```python
import sys
print(sys.executable)
```

```
/usr/local/bin/python
```

[80]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.colors as mcolors
import seaborn as sns

from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
import xgboost as xgb

from sklearn.metrics import mean_squared_error, root_mean_squared_error,r2_score
```

[81]:
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
#n_test_split
from sklearn.linear_model import LinearRegression
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
import xgboost as xgb

from sklearn.metrics import mean_squared_error, root_mean_squared_error,r2_score
```

[82]:
```python
%%capture
url = "https://ddc-datascience.s3.amazonaws.com/Projects/Project.4-Spotify/Data/
↪Spotify.csv"
!curl -s -I {url}
```

3 Data Exploration

[83]:
```
df_1 = pd.read_csv(url).copy()
```

3.1 Head

[84]:
```
df_1.head()
```

[84]:
```
   Index  Highest Charting Position  Number of Times Charted  \
0      1                          1                        8
1      2                          2                        3
2      3                          1                       11
3      4                          3                        5
4      5                          5                        1

  Week of Highest Charting                        Song Name     Streams  \
0   2021-07-23--2021-07-30                          Beggin'  48,633,449
1   2021-07-23--2021-07-30         STAY (with Justin Bieber)  47,248,719
2   2021-06-25--2021-07-02                         good 4 u  40,162,559
3   2021-07-02--2021-07-09                       Bad Habits  37,799,456
4   2021-07-23--2021-07-30  INDUSTRY BABY (feat. Jack Harlow)  33,948,454

           Artist Artist Followers                 Song ID  \
0         Måneskin          3377762  3Wrjm47oTz2sjIgck11l5e
1    The Kid LAROI          2230022  5HCyWlXZPP0y6Gqq8TgA20
2  Olivia Rodrigo          6266514  4ZtFanR9U6ndgddUvNcjcG
3       Ed Sheeran         83293380  6PQ88X9TkUIAUIZJHW2upE
4        Lil Nas X          5473565  27NovPIUIRrOZoCHxABJwK

                                       Genre  … Danceability Energy Loudness  \
0  ['indie rock italiano', 'italian pop']  …        0.714    0.8   -4.808
1                    ['australian hip hop']  …        0.591  0.764   -5.484
2                                   ['pop']  …        0.563  0.664   -5.044
3                           ['pop', 'uk pop']  …        0.808  0.897   -3.712
4              ['lgbtq+ hip hop', 'pop rap']  …        0.736  0.704   -7.409

  Speechiness Acousticness Liveness    Tempo Duration (ms) Valence  Chord
0      0.0504        0.127    0.359  134.002        211560   0.589      B
1      0.0483       0.0383    0.103  169.928        141806   0.478  C#/Db
2       0.154        0.335   0.0849  166.928        178147   0.688      A
3      0.0348       0.0469    0.364  126.026        231041   0.591      B
4      0.0615       0.0203   0.0501  149.995        212000   0.894  D#/Eb

[5 rows x 23 columns]
```

3.2 Tail

3.3 Shape

[85]:
```
df_1.shape
```

[85]:
```
(1556, 23)
```

3.4 columns

[86]:
```
df_1.columns
```

[86]:
```
Index(['Index', 'Highest Charting Position', 'Number of Times Charted',
       'Week of Highest Charting', 'Song Name', 'Streams', 'Artist',
       'Artist Followers', 'Song ID', 'Genre', 'Release Date', 'Weeks Charted',
       'Popularity', 'Danceability', 'Energy', 'Loudness', 'Speechiness',
       'Acousticness', 'Liveness', 'Tempo', 'Duration (ms)', 'Valence',
       'Chord'],
      dtype='object')
```

3.5 Dtypes

[87]:
```
df_1.dtypes
```

[87]:
```
Index                         int64
Highest Charting Position     int64
Number of Times Charted       int64
Week of Highest Charting     object
Song Name                    object
Streams                      object
Artist                       object
Artist Followers             object
Song ID                      object
Genre                        object
Release Date                 object
Weeks Charted                object
Popularity                   object
Danceability                 object
Energy                       object
Loudness                     object
Speechiness                  object
Acousticness                 object
Liveness                     object
Tempo                        object
Duration (ms)                object
Valence                      object
Chord                        object
dtype: object
```

3.6 Describe

```
[88]: df_1.describe()
```

```
[88]:              Index  Highest Charting Position  Number of Times Charted
       count  1556.000000                1556.000000              1556.000000
       mean    778.500000                  87.744216                10.668380
       std     449.322824                  58.147225                16.360546
       min       1.000000                   1.000000                 1.000000
       25%     389.750000                  37.000000                 1.000000
       50%     778.500000                  80.000000                 4.000000
       75%    1167.250000                 137.000000                12.000000
       max    1556.000000                 200.000000               142.000000
```

3.7 Isnull Sum

```
[89]: df_1.isnull().sum()
```

```
[89]: Index                        0
      Highest Charting Position    0
      Number of Times Charted      0
      Week of Highest Charting     0
      Song Name                    0
      Streams                      0
      Artist                       0
      Artist Followers             0
      Song ID                      0
      Genre                        0
      Release Date                 0
      Weeks Charted                0
      Popularity                   0
      Danceability                 0
      Energy                       0
      Loudness                     0
      Speechiness                  0
      Acousticness                 0
      Liveness                     0
      Tempo                        0
      Duration (ms)                0
      Valence                      0
      Chord                        0
      dtype: int64
```

3.8 Isna Sum

```
[90]: df_1.isna().sum()
```

[90]:
```
Index                        0
Highest Charting Position    0
Number of Times Charted      0
Week of Highest Charting     0
Song Name                    0
Streams                      0
Artist                       0
Artist Followers             0
Song ID                      0
Genre                        0
Release Date                 0
Weeks Charted                0
Popularity                   0
Danceability                 0
Energy                       0
Loudness                     0
Speechiness                  0
Acousticness                 0
Liveness                     0
Tempo                        0
Duration (ms)                0
Valence                      0
Chord                        0
dtype: int64
```

3.9 unique values

[91]:
```
df_1.count('rows').unique().sum()
```

[91]:
```
np.int64(1556)
```

[92]:
```
df_1.count('columns')
```

[92]:
```
0       23
1       23
2       23
3       23
4       23
        ..
1551    23
1552    23
1553    23
1554    23
1555    23
Length: 1556, dtype: int64
```

3.10 Sort_values

```
[93]: df_1.sort_values(by = ['Popularity'], ascending = False).head(10)
```

```
[93]:     Index  Highest Charting Position  Number of Times Charted  \
      1       2                          2                        3
      2       3                          1                       11
      3       4                          3                        5
      5       6                          1                       18
      4       5                          5                        1
      8       9                          3                        8
      14     15                          2                       10
      7       8                          2                       10
      9      10                          8                       10
      11     12                          9                        9

          Week of Highest Charting                          Song Name      Streams  \
      1    2021-07-23--2021-07-30           STAY (with Justin Bieber)  47,248,719
      2    2021-06-25--2021-07-02                            good 4 u  40,162,559
      3    2021-07-02--2021-07-09                          Bad Habits  37,799,456
      5    2021-05-07--2021-05-14      MONTERO (Call Me By Your Name)  30,071,134
      4    2021-07-23--2021-07-30  INDUSTRY BABY (feat. Jack Harlow)  33,948,454
      8    2021-06-18--2021-06-25                            Yonaguni  25,030,128
      14   2021-05-21--2021-05-28                              Butter  19,985,713
      7    2021-06-18--2021-06-25                          Todo De Ti  26,951,613
      9    2021-07-02--2021-07-09                I WANNA BE YOUR SLAVE  24,551,591
      11   2021-07-02--2021-07-09                      Qué Más Pues?  22,405,111

                             Artist Artist Followers                 Song ID  \
      1              The Kid LAROI          2230022  5HCyWlXZPP0y6Gqq8TgA20
      2             Olivia Rodrigo          6266514  4ZtFanR9U6ndgddUvNcjcG
      3                 Ed Sheeran         83293380  6PQ88X9TkUIAUIZJHW2upE
      5                  Lil Nas X          5473565  67BtfxlNbhBmCDR2L2l8qd
      4                  Lil Nas X          5473565  27NovPIUIRrOZoCHxABJwK
      8                  Bad Bunny         36142273  2JPLbjOn0wPCngEot2STUS
      14                       BTS         37106176  2bgTY4UwhfBYhGT4HUYStN
      7             Rauw Alejandro          6080597  4fSIb4hdOQ151TILNsSEaF
      9                   Måneskin          3377762  4pt5fDVTg5GhEvEtlz9dKk
      11  J Balvin, Maria Becerra         29051363  6hf0RpxTbOprT5nnwzkk8e

                                        Genre  … Danceability Energy  \
      1               ['australian hip hop']  …        0.591  0.764
      2                              ['pop']  …        0.563  0.664
      3                    ['pop', 'uk pop']  …        0.808  0.897
      5         ['lgbtq+ hip hop', 'pop rap']  …         0.61  0.508
      4         ['lgbtq+ hip hop', 'pop rap']  …        0.736  0.704
      8    ['latin', 'reggaeton', 'trap latino']  …        0.644  0.648
```

```
14                  ['k-pop', 'k-pop boy group']  …        0.759  0.459
7              ['puerto rican pop', 'trap latino']  …         0.78  0.718
9            ['indie rock italiano', 'italian pop']  …         0.75  0.608
11  ['latin', 'reggaeton', 'reggaeton colombiano']  …        0.891  0.819

   Loudness Speechiness Acousticness Liveness   Tempo Duration (ms) Valence  \
1    -5.484      0.0483       0.0383    0.103  169.928        141806   0.478
2    -5.044       0.154        0.335   0.0849  166.928        178147   0.688
3    -3.712      0.0348       0.0469    0.364  126.026        231041   0.591
5    -6.682       0.152        0.297    0.384  178.818        137876   0.758
4    -7.409      0.0615       0.0203   0.0501  149.995        212000   0.894
8    -4.601       0.118        0.276    0.135  179.951        206710    0.44
14   -5.187      0.0948      0.00323   0.0906  109.997        164442   0.695
7    -3.605      0.0506         0.31   0.0932  127.949        199604   0.342
9    -4.008      0.0387      0.00165    0.178  132.507        173347   0.958
11   -3.964       0.106       0.0261    0.173  101.968        217773   0.768

    Chord
1  C#/Db
2       A
3       B
5  G#/Ab
4  D#/Eb
8  C#/Db
14 G#/Ab
7  D#/Eb
9  C#/Db
11 G#/Ab

[10 rows x 23 columns]
```

4 Data Cleaning and Feature Engineering

4.1 New copy of dataframe

[94]:
```
df_cleaning = df_1.copy()
df_cleaning
```

[94]:
```
      Index  Highest Charting Position  Number of Times Charted  \
0         1                          1                        8
1         2                          2                        3
2         3                          1                       11
3         4                          3                        5
4         5                          5                        1
…       …                        …                      …
1551   1552                        195                        1
1552   1553                        196                        1
```

```
1553  1554                    197                     1
1554  1555                    198                     1
1555  1556                    199                     1

    Week of Highest Charting                          Song Name     Streams  \
0       2021-07-23--2021-07-30                            Beggin'  48,633,449
1       2021-07-23--2021-07-30          STAY (with Justin Bieber)  47,248,719
2       2021-06-25--2021-07-02                           good 4 u  40,162,559
3       2021-07-02--2021-07-09                         Bad Habits  37,799,456
4       2021-07-23--2021-07-30   INDUSTRY BABY (feat. Jack Harlow)  33,948,454
…                          …                                  …          …
1551    2019-12-27--2020-01-03                          New Rules   4,630,675
1552    2019-12-27--2020-01-03                 Cheirosa - Ao Vivo   4,623,030
1553    2019-12-27--2020-01-03          Havana (feat. Young Thug)   4,620,876
1554    2019-12-27--2020-01-03         Surtada - Remix Brega Funk   4,607,385
1555    2019-12-27--2020-01-03  Lover (Remix) [feat. Shawn Mendes]   4,595,450

                            Artist Artist Followers                 Song ID  \
0                         Måneskin          3377762  3Wrjm47oTz2sjIgck11l5e
1                    The Kid LAROI          2230022  5HCyWlXZPP0y6Gqq8TgA20
2                   Olivia Rodrigo          6266514  4ZtFanR9U6ndgddUvNcjcG
3                       Ed Sheeran         83293380  6PQ88X9TkUIAUIZJHW2upE
4                       Lil Nas X          5473565  27NovPIUIRrOZoCHxABJwK
…                              …                …                      …
1551                      Dua Lipa         27167675  2ekn2ttSfGqwhhate0LSR0
1552                Jorge & Mateus         15019109  2PWjKmjyTZeDpmOUa3a5da
1553                Camila Cabello         22698747  1rfofaqEpACxVEHIZBJe6W
1554  Dadá Boladão, Tati Zaqui, OIK           208630  5F8ffc8KWKNawllr5WsW0r
1555                  Taylor Swift         42227614  3i9UVldZOE0aD0JnyfAZZ0

                                                  Genre  … Danceability  \
0              ['indie rock italiano', 'italian pop']  …        0.714
1                              ['australian hip hop']  …        0.591
2                                             ['pop']  …        0.563
3                                   ['pop', 'uk pop']  …        0.808
4                      ['lgbtq+ hip hop', 'pop rap']  …        0.736
…                                                  …  …          …
1551                     ['dance pop', 'pop', 'uk pop']  …        0.762
1552           ['sertanejo', 'sertanejo universitario']  …        0.528
1553  ['dance pop', 'electropop', 'pop', 'post-teen …  …        0.765
1554                     ['brega funk', 'funk carioca']  …        0.832
1555                           ['pop', 'post-teen pop']  …        0.448

    Energy Loudness Speechiness Acousticness Liveness    Tempo Duration (ms)  \
0       0.8   -4.808      0.0504        0.127    0.359  134.002        211560
1     0.764   -5.484      0.0483       0.0383    0.103  169.928        141806
2     0.664   -5.044       0.154        0.335   0.0849  166.928        178147
```

```
3     0.897   -3.712      0.0348       0.0469    0.364  126.026          231041
4     0.704   -7.409      0.0615       0.0203   0.0501  149.995          212000
…       …        …          …            …        …        …        …
1551    0.7   -6.021      0.0694      0.00261    0.153  116.073          209320
1552   0.87   -3.123      0.0851         0.24    0.333   152.37          181930
1553  0.523   -4.333        0.03        0.184    0.132  104.988          217307
1554   0.55   -7.026      0.0587        0.249    0.182  154.064          152784
1555  0.603   -7.176       0.064        0.433   0.0862  205.272          221307

     Valence   Chord
0      0.589       B
1      0.478   C#/Db
2      0.688       A
3      0.591       B
4      0.894   D#/Eb
…      …     …
1551   0.608       A
1552   0.714       B
1553   0.394       D
1554   0.881       F
1555   0.422       G

[1556 rows x 23 columns]
```

4.2 drop Index

[95]:
```
df_cleaning.drop('Index', axis = 1, inplace = True)
#i
```

[96]:
```
df_cleaning.transpose()
```

[96]:
```
                                                                        0     \
Highest Charting Position                                                 1
Number of Times Charted                                                   8
Week of Highest Charting                             2021-07-23--2021-07-30
Song Name                                                           Beggin'
Streams                                                          48,633,449
Artist                                                             Måneskin
Artist Followers                                                    3377762
Song ID                                              3Wrjm47oTz2sjIgck11l5e
Genre                              ['indie rock italiano', 'italian pop']
Release Date                                                     2017-12-08
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                              100
Danceability                                                          0.714
Energy                                                                  0.8
Loudness                                                             -4.808
```

```
Speechiness                                                   0.0504
Acousticness                                                   0.127
Liveness                                                       0.359
Tempo                                                        134.002
Duration (ms)                                                 211560
Valence                                                        0.589
Chord                                                              B

                                                                 1     \
Highest Charting Position                                          2
Number of Times Charted                                            3
Week of Highest Charting                      2021-07-23--2021-07-30
Song Name                                STAY (with Justin Bieber)
Streams                                                   47,248,719
Artist                                                 The Kid LAROI
Artist Followers                                             2230022
Song ID                                       5HCyWlXZPP0y6Gqq8TgA20
Genre                                        ['australian hip hop']
Release Date                                              2021-07-09
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                        99
Danceability                                                   0.591
Energy                                                         0.764
Loudness                                                      -5.484
Speechiness                                                   0.0483
Acousticness                                                  0.0383
Liveness                                                       0.103
Tempo                                                        169.928
Duration (ms)                                                 141806
Valence                                                        0.478
Chord                                                         C#/Db

                                                                 2     \
Highest Charting Position                                          1
Number of Times Charted                                           11
Week of Highest Charting                      2021-06-25--2021-07-02
Song Name                                                   good 4 u
Streams                                                   40,162,559
Artist                                                Olivia Rodrigo
Artist Followers                                             6266514
Song ID                                       4ZtFanR9U6ndgddUvNcjcG
Genre                                                        ['pop']
Release Date                                              2021-05-21
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                        99
Danceability                                                   0.563
Energy                                                         0.664
```

```
Loudness                                                        -5.044
Speechiness                                                      0.154
Acousticness                                                     0.335
Liveness                                                        0.0849
Tempo                                                          166.928
Duration (ms)                                                   178147
Valence                                                          0.688
Chord                                                                A

                                                                 3    \
Highest Charting Position                                            3
Number of Times Charted                                              5
Week of Highest Charting                        2021-07-02--2021-07-09
Song Name                                                   Bad Habits
Streams                                                     37,799,456
Artist                                                      Ed Sheeran
Artist Followers                                              83293380
Song ID                                         6PQ88X9TkUIAUIZJHW2upE
Genre                                                ['pop', 'uk pop']
Release Date                                                2021-06-25
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                          98
Danceability                                                     0.808
Energy                                                           0.897
Loudness                                                        -3.712
Speechiness                                                     0.0348
Acousticness                                                    0.0469
Liveness                                                         0.364
Tempo                                                          126.026
Duration (ms)                                                   231041
Valence                                                          0.591
Chord                                                                B

                                                  4    \
Highest Charting Position                             5
Number of Times Charted                               1
Week of Highest Charting         2021-07-23--2021-07-30
Song Name                 INDUSTRY BABY (feat. Jack Harlow)
Streams                                      33,948,454
Artist                                        Lil Nas X
Artist Followers                                5473565
Song ID                          27NovPIUIRrOZoCHxABJwK
Genre                      ['lgbtq+ hip hop', 'pop rap']
Release Date                                 2021-07-23
Weeks Charted                    2021-07-23--2021-07-30
Popularity                                           96
Danceability                                      0.736
```

```
Energy                                                   0.704
Loudness                                                -7.409
Speechiness                                             0.0615
Acousticness                                            0.0203
Liveness                                                0.0501
Tempo                                                  149.995
Duration (ms)                                           212000
Valence                                                  0.894
Chord                                                    D#/Eb

                                                                  5  \
Highest Charting Position                                         1
Number of Times Charted                                          18
Week of Highest Charting                     2021-05-07--2021-05-14
Song Name                                MONTERO (Call Me By Your Name)
Streams                                                  30,071,134
Artist                                                   Lil Nas X
Artist Followers                                            5473565
Song ID                                      67BtfxlNbhBmCDR2L2l8qd
Genre                                  ['lgbtq+ hip hop', 'pop rap']
Release Date                                             2021-03-31
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                       97
Danceability                                                   0.61
Energy                                                        0.508
Loudness                                                     -6.682
Speechiness                                                   0.152
Acousticness                                                  0.297
Liveness                                                      0.384
Tempo                                                       178.818
Duration (ms)                                                137876
Valence                                                       0.758
Chord                                                         G#/Ab

                                                                  6  \
Highest Charting Position                                         3
Number of Times Charted                                          16
Week of Highest Charting                     2021-05-14--2021-05-21
Song Name                                      Kiss Me More (feat. SZA)
Streams                                                  29,356,736
Artist                                                     Doja Cat
Artist Followers                                            8640063
Song ID                                      748mdHapucXQri7IAO8yFK
Genre                                           ['dance pop', 'pop']
Release Date                                             2021-04-09
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                       94
```

```
Danceability                                                   0.762
Energy                                                         0.701
Loudness                                                      -3.541
Speechiness                                                   0.0286
Acousticness                                                   0.235
Liveness                                                       0.123
Tempo                                                        110.968
Duration (ms)                                                 208867
Valence                                                        0.742
Chord                                                          G#/Ab

                                                                   7  \
Highest Charting Position                                          2
Number of Times Charted                                           10
Week of Highest Charting                      2021-06-18--2021-06-25
Song Name                                                 Todo De Ti
Streams                                                   26,951,613
Artist                                                Rauw Alejandro
Artist Followers                                             6080597
Song ID                                       4fSIb4hdOQ151TILNsSEaF
Genre                             ['puerto rican pop', 'trap latino']
Release Date                                              2021-05-20
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                        95
Danceability                                                    0.78
Energy                                                         0.718
Loudness                                                      -3.605
Speechiness                                                   0.0506
Acousticness                                                    0.31
Liveness                                                      0.0932
Tempo                                                        127.949
Duration (ms)                                                 199604
Valence                                                        0.342
Chord                                                          D#/Eb

                                                                   8  \
Highest Charting Position                                          3
Number of Times Charted                                            8
Week of Highest Charting                      2021-06-18--2021-06-25
Song Name                                                   Yonaguni
Streams                                                   25,030,128
Artist                                                     Bad Bunny
Artist Followers                                            36142273
Song ID                                       2JPLbjOn0wPCngEot2STUS
Genre                           ['latin', 'reggaeton', 'trap latino']
Release Date                                              2021-06-04
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
```

```
Popularity                                                      96
Danceability                                                 0.644
Energy                                                       0.648
Loudness                                                    -4.601
Speechiness                                                  0.118
Acousticness                                                 0.276
Liveness                                                     0.135
Tempo                                                      179.951
Duration (ms)                                               206710
Valence                                                       0.44
Chord                                                        C#/Db

                                                              9     \
Highest Charting Position                                        8
Number of Times Charted                                         10
Week of Highest Charting                    2021-07-02--2021-07-09
Song Name                                     I WANNA BE YOUR SLAVE
Streams                                                 24,551,591
Artist                                                    Måneskin
Artist Followers                                           3377762
Song ID                                     4pt5fDVTg5GhEvEtlz9dKk
Genre                      ['indie rock italiano', 'italian pop']
Release Date                                            2021-03-19
Weeks Charted             2021-07-23--2021-07-30\n2021-07-16--2021-07-23…
Popularity                                                      95
Danceability                                                  0.75
Energy                                                       0.608
Loudness                                                    -4.008
Speechiness                                                 0.0387
Acousticness                                               0.00165
Liveness                                                     0.178
Tempo                                                      132.507
Duration (ms)                                               173347
Valence                                                      0.958
Chord                                                        C#/Db

                          …                    1546  \
Highest Charting Position …                     143
Number of Times Charted   …                       1
Week of Highest Charting  …  2019-12-27--2020-01-03
Song Name                 …                JACKBOYS
Streams                   …               5,363,493
Artist                    …                JACKBOYS
Artist Followers          …                  437907
Song ID                   …  62zKJrpbLxz6InR3tGyr7o
Genre                     …         ['rap', 'trap']
Release Date              …              2019-12-27
```

```
Weeks Charted              …  2019-12-27--2020-01-03
Popularity                 …                      56
Danceability               …                   0.413
Energy                     …                    0.13
Loudness                   …                 -25.166
Speechiness                …                  0.0336
Acousticness               …                     0.9
Liveness                   …                   0.111
Tempo                      …                 123.342
Duration (ms)              …                   46837
Valence                    …                  0.0676
Chord                      …                       C

                                                        1547  \
Highest Charting Position                                156
Number of Times Charted                                    1
Week of Highest Charting                2019-12-27--2020-01-03
Song Name                             Combatchy (feat. MC Rebecca)
Streams                                            5,149,797
Artist                                 Anitta, Lexa, Luísa Sonza
Artist Followers                                    10741972
Song ID                                 2bPtwnrpFNEe8N7Q85kLHw
Genre                      ['funk carioca', 'funk pop', 'pagode baiano', …
Release Date                                      2019-11-20
Weeks Charted                           2019-12-27--2020-01-03
Popularity                                                64
Danceability                                           0.826
Energy                                                  0.73
Loudness                                              -3.032
Speechiness                                           0.0809
Acousticness                                           0.383
Liveness                                              0.0197
Tempo                                                150.134
Duration (ms)                                         157600
Valence                                                0.605
Chord                                                  C#/Db

                                          1548  \
Highest Charting Position                  178
Number of Times Charted                      1
Week of Highest Charting    2019-12-27--2020-01-03
Song Name                        Old Town Road
Streams                              4,852,004
Artist                               Lil Nas X
Artist Followers                       5488666
Song ID                 2YpeDb67231RjR0MgVLzsG
Genre                 ['lgbtq+ hip hop', 'pop rap']
```

```
Release Date                                  2019-06-21
Weeks Charted                     2019-12-27--2020-01-03
Popularity                                            81
Danceability                                       0.878
Energy                                             0.619
Loudness                                           -5.56
Speechiness                                        0.102
Acousticness                                      0.0533
Liveness                                           0.113
Tempo                                            136.041
Duration (ms)                                     157067
Valence                                            0.639
Chord                                              F#/Gb

                                                           1549  \
Highest Charting Position                                   187
Number of Times Charted                                       1
Week of Highest Charting                 2019-12-27--2020-01-03
Song Name                  Let Me Know (I Wonder Why Freestyle)
Streams                                               4,701,532
Artist                                               Juice WRLD
Artist Followers                                       19102888
Song ID                                  3wwo0bJvDSor0pNfzEkfXx
Genre                            ['chicago rap', 'melodic rap']
Release Date                                         2019-12-07
Weeks Charted                            2019-12-27--2020-01-03
Popularity                                                   76
Danceability                                              0.635
Energy                                                    0.537
Loudness                                                 -7.895
Speechiness                                              0.0832
Acousticness                                              0.172
Liveness                                                  0.418
Tempo                                                   125.028
Duration (ms)                                            215381
Valence                                                   0.383
Chord                                                         G

                                                                        1550  \
Highest Charting Position                                                190
Number of Times Charted                                                    1
Week of Highest Charting                              2019-12-27--2020-01-03
Song Name                                                     Ne reviens pas
Streams                                                            4,676,857
Artist                                               Gradur, Heuss L'enfoiré
Artist Followers                                                     1390813
Song ID                                               4TnFANpjVwVKWzkxNzIyFH
```

```
Genre                      ['francoton', 'french hip hop', 'pop urbaine',…
Release Date                                                      2019-11-29
Weeks Charted                                         2019-12-27--2020-01-03
Popularity                                                                62
Danceability                                                           0.932
Energy                                                                 0.778
Loudness                                                              -3.384
Speechiness                                                           0.0638
Acousticness                                                           0.212
Liveness                                                               0.168
Tempo                                                                124.996
Duration (ms)                                                         188613
Valence                                                                0.933
Chord                                                                  A#/Bb

                                                     1551  \
Highest Charting Position                             195
Number of Times Charted                                 1
Week of Highest Charting           2019-12-27--2020-01-03
Song Name                                       New Rules
Streams                                         4,630,675
Artist                                           Dua Lipa
Artist Followers                                 27167675
Song ID                            2ekn2ttSfGqwhhate0LSR0
Genre                      ['dance pop', 'pop', 'uk pop']
Release Date                                   2017-06-02
Weeks Charted                      2019-12-27--2020-01-03
Popularity                                             79
Danceability                                        0.762
Energy                                                0.7
Loudness                                           -6.021
Speechiness                                        0.0694
Acousticness                                      0.00261
Liveness                                            0.153
Tempo                                             116.073
Duration (ms)                                      209320
Valence                                             0.608
Chord                                                   A

                                                               1552  \
Highest Charting Position                                       196
Number of Times Charted                                           1
Week of Highest Charting                     2019-12-27--2020-01-03
Song Name                                        Cheirosa - Ao Vivo
Streams                                                   4,623,030
Artist                                               Jorge & Mateus
Artist Followers                                           15019109
```

```
Song ID                                         2PWjKmjyTZeDpmOUa3a5da
Genre                       ['sertanejo', 'sertanejo universitario']
Release Date                                                2019-10-11
Weeks Charted                                   2019-12-27--2020-01-03
Popularity                                                          66
Danceability                                                     0.528
Energy                                                            0.87
Loudness                                                        -3.123
Speechiness                                                     0.0851
Acousticness                                                      0.24
Liveness                                                         0.333
Tempo                                                           152.37
Duration (ms)                                                   181930
Valence                                                          0.714
Chord                                                                B

                                                                      1553  \
Highest Charting Position                                             197
Number of Times Charted                                                 1
Week of Highest Charting                           2019-12-27--2020-01-03
Song Name                                        Havana (feat. Young Thug)
Streams                                                         4,620,876
Artist                                                     Camila Cabello
Artist Followers                                                 22698747
Song ID                                            1rfofaqEpACxVEHIZBJe6W
Genre                       ['dance pop', 'electropop', 'pop', 'post-teen …
Release Date                                                   2018-01-12
Weeks Charted                                      2019-12-27--2020-01-03
Popularity                                                             81
Danceability                                                        0.765
Energy                                                              0.523
Loudness                                                           -4.333
Speechiness                                                          0.03
Acousticness                                                        0.184
Liveness                                                            0.132
Tempo                                                             104.988
Duration (ms)                                                      217307
Valence                                                             0.394
Chord                                                                   D

                                                   1554  \
Highest Charting Position                          198
Number of Times Charted                              1
Week of Highest Charting        2019-12-27--2020-01-03
Song Name                     Surtada - Remix Brega Funk
Streams                                      4,607,385
Artist                         Dadá Boladão, Tati Zaqui, OIK
Artist Followers                                208630
Song ID                         5F8ffc8KWKNawllr5WsW0r
Genre                    ['brega funk', 'funk carioca']
Release Date                                2019-09-25
Weeks Charted                   2019-12-27--2020-01-03
Popularity                                          60
Danceability                                     0.832
Energy                                            0.55
Loudness                                        -7.026
Speechiness                                     0.0587
Acousticness                                     0.249
Liveness                                         0.182
Tempo                                          154.064
Duration (ms)                                   152784
Valence                                          0.881
Chord                                                F

                                                    1555
Highest Charting Position                            199
Number of Times Charted                                1
Week of Highest Charting          2019-12-27--2020-01-03
Song Name                 Lover (Remix) [feat. Shawn Mendes]
Streams                                        4,595,450
Artist                                      Taylor Swift
Artist Followers                                42227614
Song ID                           3i9UVldZOE0aD0JnyfAZZ0
Genre                           ['pop', 'post-teen pop']
Release Date                                  2019-11-13
Weeks Charted                     2019-12-27--2020-01-03
Popularity                                            70
Danceability                                       0.448
Energy                                             0.603
Loudness                                          -7.176
Speechiness                                        0.064
Acousticness                                       0.433
Liveness                                          0.0862
Tempo                                            205.272
Duration (ms)                                     221307
Valence                                            0.422
Chord                                                  G

[22 rows x 1556 columns]
```

4.3 Convert object columns with numbers to float64

[97]:
```
# List of columns to convert
columns_to_convert = ['Artist Followers', 'Streams','Popularity',␣
 ↪'Danceability', 'Energy', 'Loudness',
                      'Speechiness', 'Acousticness', 'Liveness', 'Tempo',␣
 ↪'Duration (ms)', 'Valence']

# Convert columns to numeric
for column in columns_to_convert:
    df_1[column] = pd.to_numeric(df_1[column], errors='coerce')
```

[98]:
```
df_1.dtypes
```

[98]:
```
Index                          int64
Highest Charting Position      int64
Number of Times Charted        int64
Week of Highest Charting      object
Song Name                     object
Streams                      float64
Artist                        object
Artist Followers             float64
Song ID                       object
Genre                         object
Release Date                  object
Weeks Charted                 object
Popularity                   float64
Danceability                 float64
Energy                       float64
Loudness                     float64
Speechiness                  float64
Acousticness                 float64
Liveness                     float64
Tempo                        float64
Duration (ms)                float64
Valence                      float64
Chord                         object
dtype: object
```

5 Data Cleaning Continued: Prepare DataFrame for Modeling and Training

[99]:
```
df_1 = df_1.drop("Index", axis = 1)
```

[100]:
```
df_1
```

```
[100]:      Highest Charting Position  Number of Times Charted  \
     0                            1                        8
     1                            2                        3
     2                            1                       11
     3                            3                        5
     4                            5                        1
     …                          …                      …
     1551                       195                        1
     1552                       196                        1
     1553                       197                        1
     1554                       198                        1
     1555                       199                        1

         Week of Highest Charting                          Song Name  Streams  \
     0     2021-07-23--2021-07-30                            Beggin'      NaN
     1     2021-07-23--2021-07-30          STAY (with Justin Bieber)      NaN
     2     2021-06-25--2021-07-02                           good 4 u      NaN
     3     2021-07-02--2021-07-09                         Bad Habits      NaN
     4     2021-07-23--2021-07-30   INDUSTRY BABY (feat. Jack Harlow)      NaN
     …                      …                              …       …
     1551  2019-12-27--2020-01-03                          New Rules      NaN
     1552  2019-12-27--2020-01-03                 Cheirosa - Ao Vivo      NaN
     1553  2019-12-27--2020-01-03         Havana (feat. Young Thug)      NaN
     1554  2019-12-27--2020-01-03          Surtada - Remix Brega Funk      NaN
     1555  2019-12-27--2020-01-03  Lover (Remix) [feat. Shawn Mendes]      NaN

                             Artist  Artist Followers                 Song ID  \
     0                     Måneskin         3377762.0  3Wrjm47oTz2sjIgck11l5e
     1                The Kid LAROI         2230022.0  5HCyWlXZPP0y6Gqq8TgA20
     2               Olivia Rodrigo         6266514.0  4ZtFanR9U6ndgddUvNcjcG
     3                   Ed Sheeran        83293380.0  6PQ88X9TkUIAUIZJHW2upE
     4                   Lil Nas X         5473565.0  27NovPIUIRrOZoCHxABJwK
     …                          …               …                     …
     1551                  Dua Lipa        27167675.0  2ekn2ttSfGqwhhate0LSR0
     1552            Jorge & Mateus        15019109.0  2PWjKmjyTZeDpmOUa3a5da
     1553            Camila Cabello        22698747.0  1rfofaqEpACxVEHIZBJe6W
     1554  Dadá Boladão, Tati Zaqui, OIK      208630.0  5F8ffc8KWKNawllr5WsW0r
     1555              Taylor Swift        42227614.0  3i9UVldZOE0aD0JnyfAZZ0

                                          Genre Release Date  …  \
     0      ['indie rock italiano', 'italian pop']   2017-12-08  …
     1                    ['australian hip hop']   2021-07-09  …
     2                                  ['pop']   2021-05-21  …
     3                         ['pop', 'uk pop']   2021-06-25  …
     4               ['lgbtq+ hip hop', 'pop rap']   2021-07-23  …
     …                                       …           …  …
     1551             ['dance pop', 'pop', 'uk pop']   2017-06-02  …
```

```
1552           ['sertanejo', 'sertanejo universitario']   2019-10-11  …
1553  ['dance pop', 'electropop', 'pop', 'post-teen …   2018-01-12  …
1554                      ['brega funk', 'funk carioca']   2019-09-25  …
1555                            ['pop', 'post-teen pop']   2019-11-13  …

     Danceability  Energy  Loudness  Speechiness  Acousticness  Liveness  \
0           0.714   0.800    -4.808       0.0504       0.12700    0.3590
1           0.591   0.764    -5.484       0.0483       0.03830    0.1030
2           0.563   0.664    -5.044       0.1540       0.33500    0.0849
3           0.808   0.897    -3.712       0.0348       0.04690    0.3640
4           0.736   0.704    -7.409       0.0615       0.02030    0.0501
…             …      …        …           …             …          …
1551        0.762   0.700    -6.021       0.0694       0.00261    0.1530
1552        0.528   0.870    -3.123       0.0851       0.24000    0.3330
1553        0.765   0.523    -4.333       0.0300       0.18400    0.1320
1554        0.832   0.550    -7.026       0.0587       0.24900    0.1820
1555        0.448   0.603    -7.176       0.0640       0.43300    0.0862

        Tempo  Duration (ms)  Valence   Chord
0     134.002       211560.0    0.589       B
1     169.928       141806.0    0.478  C#/Db
2     166.928       178147.0    0.688       A
3     126.026       231041.0    0.591       B
4     149.995       212000.0    0.894  D#/Eb
…       …              …      …      …
1551  116.073       209320.0    0.608       A
1552  152.370       181930.0    0.714       B
1553  104.988       217307.0    0.394       D
1554  154.064       152784.0    0.881       F
1555  205.272       221307.0    0.422       G

[1556 rows x 22 columns]
```

[101]:
```
df_clean_2 = df_1.copy()
```

5.1 Identify Object Columns & Drop them

[102]:
```
object_columns = df_clean_2.select_dtypes(include=['object']).columns
df_clean_2 = df_clean_2.drop(columns=object_columns)
```

[103]:
```
df_clean_2.isnull().sum()
```

[103]:
```
Highest Charting Position       0
Number of Times Charted         0
Streams                      1556
Artist Followers               11
Popularity                     11
```

```
Danceability                 11
Energy                       11
Loudness                     11
Speechiness                  11
Acousticness                 11
Liveness                     11
Tempo                        11
Duration (ms)                11
Valence                      11
dtype: int64
```

[104]:
```
df_clean_2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1556 entries, 0 to 1555
Data columns (total 14 columns):
 #   Column                     Non-Null Count  Dtype  
---  ------                     --------------  -----  
 0   Highest Charting Position  1556 non-null   int64  
 1   Number of Times Charted    1556 non-null   int64  
 2   Streams                    0 non-null      float64
 3   Artist Followers           1545 non-null   float64
 4   Popularity                 1545 non-null   float64
 5   Danceability               1545 non-null   float64
 6   Energy                     1545 non-null   float64
 7   Loudness                   1545 non-null   float64
 8   Speechiness                1545 non-null   float64
 9   Acousticness               1545 non-null   float64
 10  Liveness                   1545 non-null   float64
 11  Tempo                      1545 non-null   float64
 12  Duration (ms)              1545 non-null   float64
 13  Valence                    1545 non-null   float64
dtypes: float64(12), int64(2)
memory usage: 170.3 KB
```

5.2 Drop Streams Column (essentially empty)

[105]:
```
df_clean_2.drop('Streams', axis = 1, inplace = True)
```

[106]:
```
df_clean_2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1556 entries, 0 to 1555
Data columns (total 13 columns):
 #   Column                     Non-Null Count  Dtype  
---  ------                     --------------  -----  
 0   Highest Charting Position  1556 non-null   int64  
 1   Number of Times Charted    1556 non-null   int64  
 2   Artist Followers          1545 non-null   float64
 3   Popularity                1545 non-null   float64
 4   Danceability              1545 non-null   float64
 5   Energy                    1545 non-null   float64
 6   Loudness                  1545 non-null   float64
 7   Speechiness               1545 non-null   float64
 8   Acousticness              1545 non-null   float64
 9   Liveness                  1545 non-null   float64
 10  Tempo                     1545 non-null   float64
 11  Duration (ms)             1545 non-null   float64
 12  Valence                   1545 non-null   float64
dtypes: float64(11), int64(2)
memory usage: 158.2 KB
```

5.3 Get means and replace null values with mean per column

[107]:
```
df_clean_2.isna().sum()
```

[107]:
```
Highest Charting Position     0
Number of Times Charted       0
Artist Followers             11
Popularity                   11
Danceability                 11
Energy                       11
Loudness                     11
Speechiness                  11
Acousticness                 11
Liveness                     11
Tempo                        11
Duration (ms)                11
Valence                      11
dtype: int64
```

[108]:
```
null_columns = df_clean_2.columns[df_clean_2.isnull().any()].tolist()
print("Columns with null values:")
null_columns
```

```
Columns with null values:
```

[108]:
```
['Artist Followers',
 'Popularity',
 'Danceability',
 'Energy',
 'Loudness',
 'Speechiness',
 'Acousticness',
 'Liveness',
 'Tempo',
 'Duration (ms)',
 'Valence']
```

[109]:
```
for col in null_columns:
    #Calculate the mean, exluding NaN values
    mean= df_clean_2[col].mean(skipna=True)

    #replace NaNs with the mean per column
    df_clean_2[col] = df_clean_2[col].fillna(mean)
```

[110]:
```
print("\nNull value count after replacement:")
print(df_clean_2.isnull().sum())
```

```

Null value count after replacement:
Highest Charting Position    0
Number of Times Charted      0
Artist Followers             0
Popularity                   0
Danceability                 0
Energy                       0
Loudness                     0
Speechiness                  0
Acousticness                 0
Liveness                     0
Tempo                        0
Duration (ms)                0
Valence                      0
dtype: int64
```

[111]:
```
df_clean_2.dtypes
```

[111]:
```
Highest Charting Position      int64
Number of Times Charted        int64
Artist Followers             float64
Popularity                   float64
Danceability                 float64
Energy                       float64
Loudness                     float64
Speechiness                  float64
Acousticness                 float64
Liveness                     float64
Tempo                        float64
Duration (ms)                float64
Valence                      float64
dtype: object
```

5.4 Drop columns that have no relation to target = "Popularity"

```
[112]: # df_clean_2.drop('Highest Charting Position', axis = 1, inplace = True)
```

```
[113]: # df_clean_2.drop('Number of Times Charted', axis = 1, inplace = True)
```

```
[114]: # df_clean_2.drop('Artist Followers', axis = 1, inplace = True)
```

```
[115]: df_scaling = df_clean_2.copy()
```

6 Data Scaling

6.1 Data Scaling (standard scaler)

6.1.1 Setup standard scaled training and testing data

```
[116]: df_3_std = df_scaling.copy()
```

```
[117]: x1 = df_3_std.drop(['Popularity'], axis=1)
y1 = df_3_std['Popularity']

X_train_1, X_test_1, y_train_1, y_test_1 = train_test_split(x1, y1, test_size=0.
 ↪2)
```

```
[118]: scaler = StandardScaler()
X_train_std = scaler.fit_transform(X_train_1)
X_test_std = scaler.transform(X_test_1)
```

```
[119]: print("Before scaling:")
print(X_train_1.describe())

print("\nAfter scaling:")
print(pd.DataFrame(X_train_std).describe())
```

```
Before scaling:
       Highest Charting Position  Number of Times Charted  Artist Followers  \
count                1244.000000              1244.000000      1.244000e+03
mean                   87.947749                10.411576      1.488270e+07
std                    58.071388                16.142898      1.674752e+07
min                     1.000000                 1.000000      4.883000e+03
25%                    38.000000                 1.000000      2.147875e+06
50%                    80.000000                 4.000000      6.852509e+06
75%                   136.000000                12.000000      2.384846e+07
max                   200.000000               142.000000      8.333778e+07

       Danceability       Energy     Loudness  Speechiness  Acousticness  \
count   1244.000000  1244.000000  1244.000000  1244.000000   1244.000000
mean       0.689953     0.631982    -6.339040     0.123921      0.244967
std        0.142210     0.160238     2.510959     0.109680      0.245850
```

```
min        0.184000     0.054000   -25.166000     0.023200      0.000025
25%        0.598750     0.531750    -7.476000     0.045775      0.048800
50%        0.707500     0.640000    -5.937500     0.076550      0.162500
75%        0.794000     0.747000    -4.724500     0.164250      0.373250
max        0.980000     0.970000     1.509000     0.884000      0.994000

          Liveness        Tempo  Duration (ms)      Valence
count  1244.000000  1244.000000    1244.000000  1244.000000
mean      0.182372   123.348917  197695.595432     0.511095
std       0.145781    29.564032   47432.248412     0.225470
min       0.019700    46.718000   30133.000000     0.032000
25%       0.097175    98.030000  168716.500000     0.340750
50%       0.125000   122.811023  192982.500000     0.509500
75%       0.216250   143.909500  218162.750000     0.679250
max       0.944000   205.272000  588139.000000     0.977000

After scaling:
                 0             1            2             3             4  \
count  1.244000e+03  1.244000e+03  1244.000000  1.244000e+03  1.244000e+03
mean   1.028116e-16  5.140582e-17     0.000000 -3.998231e-17  3.641246e-16
std    1.000402e+00  1.000402e+00     1.000402  1.000402e+00  1.000402e+00
min   -1.497858e+00 -5.832510e-01    -0.888717 -3.559230e+00 -3.608463e+00
25%   -8.604554e-01 -5.832510e-01    -0.760706 -6.415883e-01 -6.257688e-01
50%   -1.369167e-01 -3.973360e-01    -0.479678  1.234354e-01  5.005877e-02
75%    8.278014e-01  9.843730e-02     0.535564  7.319370e-01  7.180823e-01
max    1.930336e+00  8.154753e+00     4.089119  2.040391e+00  2.110318e+00

                 5             6             7             8             9  \
count  1.244000e+03  1.244000e+03  1.244000e+03  1.244000e+03  1.244000e+03
mean   4.783598e-17  7.139698e-17 -5.711758e-17  7.925065e-17  3.012953e-16
std    1.000402e+00  1.000402e+00  1.000402e+00  1.000402e+00  1.000402e+00
min   -7.500930e+00 -9.186839e-01 -9.967049e-01 -1.116319e+00 -2.593074e+00
25%   -4.529810e-01 -7.127753e-01 -7.982338e-01 -5.846565e-01 -8.567539e-01
50%    1.599795e-01 -4.320736e-01 -3.355707e-01 -3.937108e-01 -1.820152e-02
75%    6.432560e-01  3.678463e-01  5.220041e-01  2.324812e-01  6.957390e-01
max    3.126772e+00  6.932753e+00  3.047933e+00  5.226577e+00  2.772153e+00

                10            11
count  1.244000e+03  1.244000e+03
mean  -4.640804e-16  1.413660e-16
std    1.000402e+00  1.000402e+00
min   -3.534093e+00 -2.125723e+00
25%   -6.112034e-01 -7.558133e-01
50%   -9.940475e-02 -7.077110e-03
75%    4.316765e-01  7.460961e-01
max    8.234913e+00  2.067199e+00
```

```
[120]: print("Mean:", X_train_std.mean(axis=0))
       print("Std:", X_train_std.std(axis=0))
```

```
Mean: [ 1.02811650e-16  5.14058249e-17  0.00000000e+00 -3.99823083e-17
  3.64124593e-16  4.78359760e-17  7.13969791e-17 -5.71175833e-17
  7.92506468e-17  3.01295252e-16 -4.64080364e-16  1.41366019e-16]
Std: [1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
```

6.2 Data Scaling Continued (min-max scaler)

```
[121]: df_3_mm = df_scaling.copy()
```

```
[122]: x2 = df_3_mm.drop(['Popularity'], axis=1)
       y2 = df_3_mm['Popularity']

       X_train_2, X_test_2, y_train_2, y_test_2 = train_test_split(x2, y2, test_size=0.
        ↪2)
```

6.2.1 Setup mm scaled training and testing data

```
[123]: scaler = MinMaxScaler()
       X_train_mm = scaler.fit_transform(X_train_2)
       X_test_mm = scaler.transform(X_test_2)
```

```
[124]: print("Before scaling:")
       print(X_train_2.describe())

       print("\nAfter scaling:")
       print(pd.DataFrame(X_train_mm).describe())
```

```
Before scaling:
       Highest Charting Position  Number of Times Charted  Artist Followers  \
count                1244.000000              1244.000000      1.244000e+03
mean                   87.207395                10.583601      1.453348e+07
std                    57.959556                16.245955      1.615339e+07
min                     1.000000                 1.000000      1.412200e+04
25%                    38.000000                 1.000000      2.195782e+06
50%                    78.500000                 4.000000      7.408249e+06
75%                   136.250000                12.000000      2.199438e+07
max                   200.000000               142.000000      8.333778e+07

       Danceability       Energy     Loudness  Speechiness  Acousticness  \
count   1244.000000  1244.000000  1244.000000  1244.000000   1244.000000
mean       0.689942     0.634705    -6.332446     0.122113      0.244431
std        0.140878     0.159418     2.471089     0.108160      0.247692
min        0.184000     0.054000   -25.166000     0.023200      0.000038
25%        0.600000     0.534000    -7.459250     0.045700      0.047475
50%        0.704500     0.645000    -5.992500     0.076950      0.159000
```

```
75%        0.794000    0.749250   -4.718500    0.164000     0.369000
max        0.980000    0.966000    1.509000    0.884000     0.994000

          Liveness        Tempo  Duration (ms)      Valence
count  1244.000000  1244.000000    1244.000000  1244.000000
mean      0.178614   122.555188  198105.851569     0.512352
std       0.141172    29.375796   47767.990782     0.229061
min       0.019700    46.718000   30583.000000     0.036000
25%       0.095500    97.911750  169855.750000     0.339000
50%       0.124000   121.994500  193406.500000     0.508500
75%       0.209250   142.963500  218096.500000     0.691000
max       0.962000   203.903000  588139.000000     0.979000

After scaling:
                0            1            2            3            4  \
count  1244.000000  1244.000000  1244.000000  1244.000000  1244.000000
mean      0.433203     0.067969     0.174253     0.635606     0.636737
std       0.291254     0.115220     0.193863     0.176982     0.174800
min       0.000000     0.000000     0.000000     0.000000     0.000000
25%       0.185930     0.000000     0.026183     0.522613     0.526316
50%       0.389447     0.021277     0.088740     0.653894     0.648026
75%       0.679648     0.078014     0.263794     0.766332     0.762336
max       1.000000     1.000000     1.000000     1.000000     1.000000

                5            6            7            8            9  \
count  1244.000000  1244.000000  1244.000000  1244.000000  1244.000000
mean      0.706038     0.114909     0.245878     0.168645     0.482471
std       0.092637     0.125651     0.249197     0.149816     0.186887
min       0.000000     0.000000     0.000000     0.000000     0.000000
25%       0.663796     0.026138     0.047725     0.080441     0.325691
50%       0.718782     0.062442     0.159927     0.110687     0.478904
75%       0.766542     0.163569     0.371203     0.201157     0.612307
max       1.000000     1.000000     1.000000     1.000000     1.000000

               10           11
count  1244.000000  1244.000000
mean      0.300459     0.505146
std       0.085674     0.242906
min       0.000000     0.000000
25%       0.249792     0.321315
50%       0.292031     0.501060
75%       0.336313     0.694592
max       1.000000     1.000000
```

[125]:
```
print("Mean:", X_train_mm.mean(axis=0))
print("Std:", X_train_mm.std(axis=0))
```

```
Mean: [0.43320299 0.0679688  0.17425254 0.63560565 0.63673744 0.70603762
```

```
 0.11490863 0.24587771 0.16864524 0.4824709  0.30045924 0.50514575]
Std: [0.29113696 0.11517322 0.19378524 0.17691083 0.17473011 0.09259964
 0.12560018 0.24909694 0.14975597 0.18681164 0.08563945 0.24280861]
```

7 Model Selection and Training

7.1 Models: STD Scaler

7.1.1 Linear Regression std scaler

[126]:
```
lr_model = LinearRegression()
lr_model.fit(X_train_std, y_train_1)
y_pred_lr = lr_model.predict(X_test_std)
print('Linear Regression:')
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_1,y_pred_lr)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_1,y_pred_lr):.2f}")
```

```
Linear Regression:
RMSE: 15.29%
R2 Score: 0.08
```

Cross Validation Score for Linear Regression

[127]:
```
lr_model = LinearRegression()
cv_scores = cross_val_score(lr_model, X_train_1, y_train_1, cv=5,␣
 ↪scoring='neg_mean_squared_error')
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 15.06
```

7.1.2 Decision Tree Model std scaler

[128]:
```
dt_model = DecisionTreeRegressor()
dt_model.fit(X_train_std, y_train_1)
y_pred_dt = dt_model.predict(X_test_std)

print("\nDecision Tree:")
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_1, y_pred_dt)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_1, y_pred_dt):.2f}")
```

```

Decision Tree:
RMSE: 12.22%
R2 Score: 0.41
```

Cross Validation Score for Decision Tree

[129]:
```
dt_model = DecisionTreeRegressor()
cv_scores = cross_val_score(dt_model, X_train_std, y_train_1, cv=5,␣
 ↪scoring='neg_mean_squared_error')
```

```
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 12.23
```

Feature Importance for Decision Tree

[130]:
```
dt_model.fit(X_train_std, y_train_1)

feature_importances = dt_model.feature_importances_
feature_names = X_train_1.columns
feature_importance_df = pd.DataFrame({'feature': feature_names, 'importance':␣
 ↪feature_importances})
feature_importance_df = feature_importance_df.sort_values('importance',␣
 ↪ascending=False)
print(feature_importance_df)
```

```
                      feature  importance
2           Artist Followers    0.593164
1      Number of Times Charted    0.130210
0    Highest Charting Position    0.045650
3                 Danceability    0.041520
5                     Loudness    0.041450
11                     Valence    0.034653
7                 Acousticness    0.022435
6                  Speechiness    0.022028
8                     Liveness    0.021440
4                       Energy    0.020456
10                Duration (ms)    0.013568
9                        Tempo    0.013425
```

7.1.3 Random Forest Model std scaler

[131]:
```
rf_model = RandomForestRegressor(n_estimators=100)
rf_model.fit(X_train_std, y_train_1)
y_pred_rf = rf_model.predict(X_test_std)

print("\nRandom Forest:")
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_1, y_pred_rf)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_1, y_pred_rf):.2f}")
```

```

Random Forest:
RMSE: 9.39%
R2 Score: 0.65
```

Cross Validation Score for Random Forest

[132]:
```
rf_model = RandomForestRegressor(n_estimators=100)
```

```
cv_scores = cross_val_score(rf_model, X_train_1, y_train_1, cv=5,␣
    ↪scoring='neg_mean_squared_error')
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 9.40
```

Feature Importance for Random Forest

[133]:
```
rf_model.fit(X_train_std, y_train_1)

feature_importances = rf_model.feature_importances_
feature_names = X_train_1.columns
feature_importance_df = pd.DataFrame({'feature': feature_names, 'importance':␣
    ↪feature_importances})
feature_importance_df = feature_importance_df.sort_values('importance',␣
    ↪ascending=False)
print(feature_importance_df)
```

```
                     feature  importance
2           Artist Followers    0.530677
1      Number of Times Charted    0.133840
0    Highest Charting Position    0.047118
5                   Loudness    0.046705
3               Danceability    0.045200
8                   Liveness    0.037390
11                   Valence    0.033850
10             Duration (ms)    0.030384
4                     Energy    0.025479
7               Acousticness    0.024932
6                Speechiness    0.024665
9                      Tempo    0.019759
```

7.1.4 XGBoost Model std scaler

[134]:
```
xgb_model = xgb.XGBRegressor(n_estimators=100)
xgb_model.fit(X_train_std, y_train_1)
y_pred_xgb = xgb_model.predict(X_test_std)

print("\nXGBoost:")
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_1, y_pred_xgb)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_1, y_pred_xgb):.2f}")
```

```

XGBoost:
RMSE: 9.78%
R2 Score: 0.62
```

Cross Validation Score for XGBoost

```
[135]: xgb_model = RandomForestRegressor(n_estimators=100)
       cv_scores = cross_val_score(rf_model, X_train_std, y_train_1, cv=5,␣
        ↪scoring='neg_mean_squared_error')
       rmse = np.sqrt(-cv_scores.mean())
       print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 9.13
```

Feature Importance for XGBoost

```
[136]: xgb_model.fit(X_train_std, y_train_1)

       feature_importances = xgb_model.feature_importances_
       feature_importance_df = pd.DataFrame({'feature': feature_names, 'importance':␣
        ↪feature_importances})
       feature_importance_df = feature_importance_df.sort_values('importance',␣
        ↪ascending=False)
       print(feature_importance_df)
```

```
                     feature  importance
2           Artist Followers    0.539350
1     Number of Times Charted    0.134860
0   Highest Charting Position    0.045110
3               Danceability    0.044476
5                   Loudness    0.043865
8                   Liveness    0.034587
11                   Valence    0.033638
10             Duration (ms)    0.030790
7               Acousticness    0.026305
6                Speechiness    0.024465
4                     Energy    0.023735
9                      Tempo    0.018820
```

7.1.5 STD Model Comparison Table

[137]:
```
results = {
    'Model': ['Linear Regression', 'Decision Tree', 'Random Forest', 'XGBoost'],
    'RMSE': [np.sqrt(mean_squared_error(y_test_1, y_pred_lr)),
             np.sqrt(mean_squared_error(y_test_1, y_pred_dt)),
             np.sqrt(mean_squared_error(y_test_1, y_pred_rf)),
             np.sqrt(mean_squared_error(y_test_1, y_pred_xgb))],
    'R2 Score': [r2_score(y_test_1, y_pred_lr),
                 r2_score(y_test_1, y_pred_dt),
                 r2_score(y_test_1, y_pred_rf),
                 r2_score(y_test_1, y_pred_xgb)]
}

results_df = pd.DataFrame(results)
print(results_df)
```

```
               Model       RMSE  R2 Score
0  Linear Regression  15.285921  0.084288
1      Decision Tree  12.224103  0.414388
2      Random Forest   9.391089  0.654373
3            XGBoost   9.782903  0.624931
```

7.2 Models: MM Scaler

7.2.1 Linear Regression mm scaler

[138]:
```
lr_model = LinearRegression()
lr_model.fit(X_train_mm, y_train_2)
y_pred_lr = lr_model.predict(X_test_mm)
print('Linear Regression:')
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_2,y_pred_lr)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_2,y_pred_lr):.2f}")
```

```
Linear Regression:
RMSE: 13.38%
R2 Score: 0.19
```

Cross Validation Score for Linear Regression mm

[139]:
```
lr_model = LinearRegression()
cv_scores = cross_val_score(lr_model, X_train_mm, y_train_2, cv=5,␣
 ↪scoring='neg_mean_squared_error')
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 15.59
```

7.2.2 Decision Tree mm scaler

[140]:
```
dt_model = DecisionTreeRegressor()
dt_model.fit(X_train_mm, y_train_2)
y_pred_dt = dt_model.predict(X_test_mm)

print("\nDecision Tree:")
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_2, y_pred_dt)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_2, y_pred_dt):.2f}")
```

```
Decision Tree:
RMSE: 11.82%
R2 Score: 0.37
```

Cross Validation Score for Decision Tree mm

[141]:
```
cv_scores = cross_val_score(dt_model, X_train_mm, y_train_2, cv=5,␣
  ↪scoring='neg_mean_squared_error')
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 12.23
```

Feature Importance for Decision Tree mm

[142]:
```
dt_model.fit(X_train_mm, y_train_2)

feature_importances = dt_model.feature_importances_
feature_names = X_train_2.columns
feature_importance_df = pd.DataFrame({'feature': feature_names, 'importance':␣
  ↪feature_importances})
feature_importance_df = feature_importance_df.sort_values('importance',␣
  ↪ascending=False)
print(feature_importance_df)
```

```
                      feature  importance
2           Artist Followers    0.606638
1      Number of Times Charted    0.138806
0    Highest Charting Position    0.038718
3                Danceability    0.036680
5                    Loudness    0.028832
4                      Energy    0.025723
9                       Tempo    0.023751
11                    Valence    0.023192
8                    Liveness    0.022374
6                 Speechiness    0.021834
10                Duration (ms)    0.019587
7                Acousticness    0.013867
```

7.2.3 Random Forest mm scaler

```
[143]: rf_model = RandomForestRegressor(n_estimators=100)
rf_model.fit(X_train_mm, y_train_2)
y_pred_rf = rf_model.predict(X_test_mm)

print("\nRandom Forest:")
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_2, y_pred_rf)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_2, y_pred_rf):.2f}")
```

```
Random Forest:
RMSE: 9.60%
R2 Score: 0.58
```

Cross Validation Score Random Forest mm

```
[144]: rf_model = RandomForestRegressor(n_estimators=100)
cv_scores = cross_val_score(rf_model, X_train_2, y_train_2, cv=5,␣
  ↪scoring='neg_mean_squared_error')
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 9.12
```

Feature Importance for Random Forest mm

```
[145]: rf_model.fit(X_train_mm, y_train_2)

feature_importances = rf_model.feature_importances_
feature_names = X_train_2.columns
feature_importance_df = pd.DataFrame({'feature': feature_names, 'importance':␣
  ↪feature_importances})
feature_importance_df = feature_importance_df.sort_values('importance',␣
  ↪ascending=False)
print(feature_importance_df)
```

```
                      feature  importance
2            Artist Followers    0.591136
1       Number of Times Charted    0.128806
3               Danceability    0.041964
0    Highest Charting Position    0.038466
5                   Loudness    0.035014
6                Speechiness    0.028702
4                     Energy    0.025599
7               Acousticness    0.023847
10               Duration (ms)    0.023117
8                   Liveness    0.023044
11                   Valence    0.022643
9                      Tempo    0.017663
```

7.2.4 XGBoost mm scaler

```
[146]: xgb_model = xgb.XGBRegressor(n_estimators=100)
xgb_model.fit(X_train_mm, y_train_2)
y_pred_xgb = xgb_model.predict(X_test_mm)

print("\nXGBoost:")
print(f"RMSE: {np.sqrt(mean_squared_error(y_test_2, y_pred_xgb)) :.2f}%")
print(f"R2 Score: {r2_score(y_test_2, y_pred_xgb):.2f}")
```

```

XGBoost:
RMSE: 11.27%
R2 Score: 0.43
```

Cross Validation Score for XGBoost mm

```
[170]: xgb_model = xgb.XGBRegressor(n_estimators=100)
cv_scores = cross_val_score(rf_model, X_train_2, y_train_2, cv=5,␣
 ↪scoring='neg_mean_squared_error')
rmse = np.sqrt(-cv_scores.mean())
print(f"Cross-validated RMSE: {rmse:.2f}")
```

```
Cross-validated RMSE: 9.11
```

Feature Importance for XGBoost mm

```
[169]: xgb_model.fit(X_train_mm, y_train_2)

feature_importances = xgb_model.feature_importances_
feature_names = X_train_2.columns
feature_importance_df = pd.DataFrame({'feature': feature_names, 'importance':␣
 ↪feature_importances})
feature_importance_df = feature_importance_df.sort_values('importance',␣
 ↪ascending=False)
print(feature_importance_df)
```

```
                     feature  importance
2           Artist Followers    0.509329
1     Number of Times Charted    0.193884
3               Danceability    0.054462
5                   Loudness    0.037472
6                Speechiness    0.033385
4                     Energy    0.028730
7               Acousticness    0.028669
0   Highest Charting Position    0.027535
10               Duration (ms)    0.024906
11                    Valence    0.023318
8                   Liveness    0.020065
9                      Tempo    0.018244
```

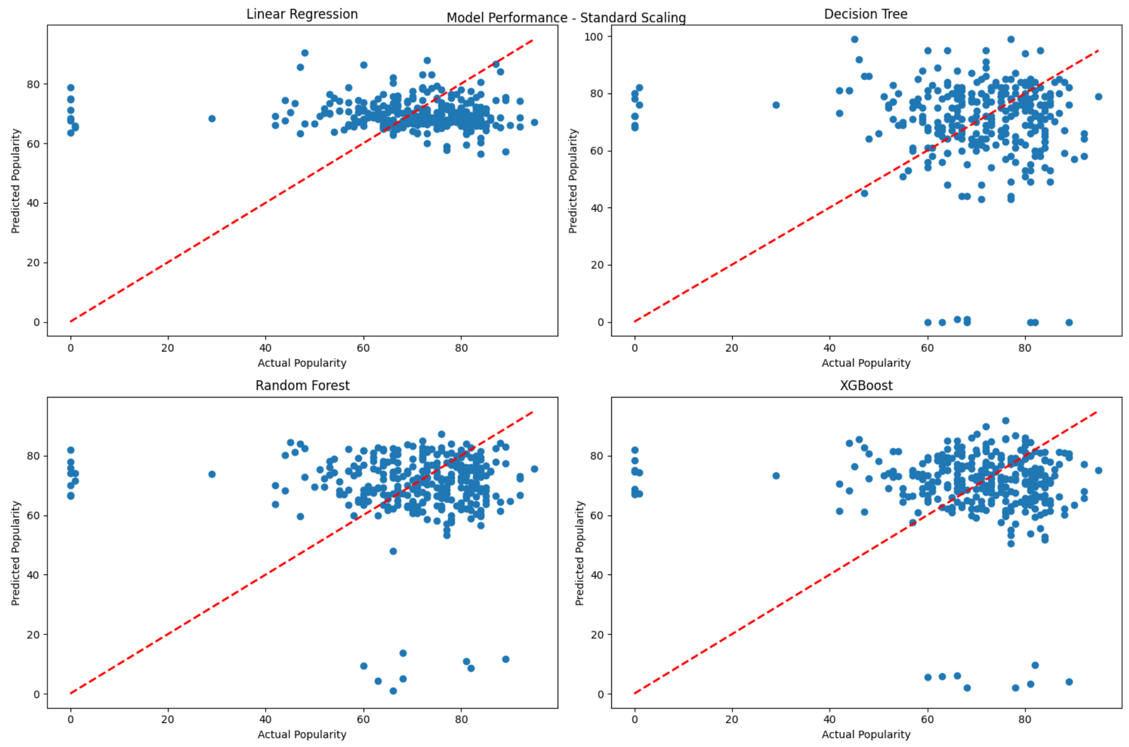
7.2.5 MM Model Comparison Table

[173]:
```
results = {
    'Model': ['Linear Regression', 'Decision Tree', 'Random Forest', 'XGBoost'],
    'RMSE': [np.sqrt(mean_squared_error(y_test_2, y_pred_lr)),
             np.sqrt(mean_squared_error(y_test_2, y_pred_dt)),
             np.sqrt(mean_squared_error(y_test_2, y_pred_rf)),
             np.sqrt(mean_squared_error(y_test_2, y_pred_xgb))],
    'R2 Score': [r2_score(y_test_2, y_pred_lr),
                 r2_score(y_test_2, y_pred_dt),
                 r2_score(y_test_2, y_pred_rf),
                 r2_score(y_test_2, y_pred_xgb)]
}

results_df = pd.DataFrame(results)
print(results_df)
```

```
               Model       RMSE  R2 Score
0  Linear Regression  13.379864  0.191110
1      Decision Tree  11.819487  0.368776
2      Random Forest   9.602155  0.583396
3            XGBoost  11.265075  0.426605
```

7.3 Model Plotting STD Scaler

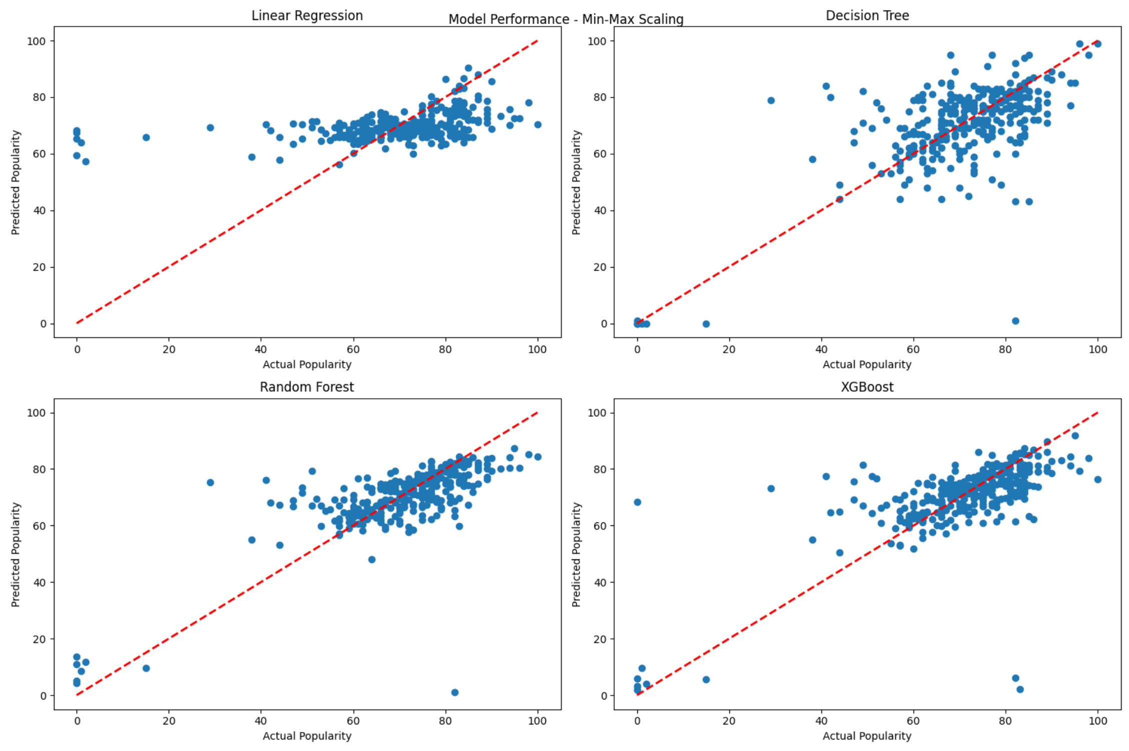
[150]:
```
plt.figure(figsize=(15, 10))

plt.subplot(2, 2, 1)
plt.scatter(y_test_1, y_pred_lr)
plt.plot([y_test_1.min(), y_test_1.max()], [y_test_1.min(), y_test_1.max()],␣
  ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('Linear Regression')

plt.subplot(2, 2, 2)
plt.scatter(y_test_1, y_pred_dt)
plt.plot([y_test_1.min(), y_test_1.max()], [y_test_1.min(), y_test_1.max()],␣
  ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('Decision Tree')

plt.subplot(2, 2, 3)
plt.scatter(y_test_1, y_pred_rf)
plt.plot([y_test_1.min(), y_test_1.max()], [y_test_1.min(), y_test_1.max()],␣
  ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('Random Forest')

plt.subplot(2, 2, 4)
plt.scatter(y_test_1, y_pred_xgb)
plt.plot([y_test_1.min(), y_test_1.max()], [y_test_1.min(), y_test_1.max()],␣
 ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('XGBoost')

plt.tight_layout()
plt.suptitle('Model Performance - Standard Scaling')
plt.show()
```



7.4 Model Plotting MinMax Scaler

[151]:
```
plt.figure(figsize=(15, 10))

plt.subplot(2, 2, 1)
plt.scatter(y_test_2, y_pred_lr)
plt.plot([y_test_2.min(), y_test_2.max()], [y_test_2.min(), y_test_2.max()],␣
 ↪'r--', lw=2)
```

```
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('Linear Regression')

plt.subplot(2, 2, 2)
plt.scatter(y_test_2, y_pred_dt)
plt.plot([y_test_2.min(), y_test_2.max()], [y_test_2.min(), y_test_2.max()],␣
  ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('Decision Tree')

plt.subplot(2, 2, 3)
plt.scatter(y_test_2, y_pred_rf)
plt.plot([y_test_2.min(), y_test_2.max()], [y_test_2.min(), y_test_2.max()],␣
  ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('Random Forest')

plt.subplot(2, 2, 4)
plt.scatter(y_test_2, y_pred_xgb)
plt.plot([y_test_2.min(), y_test_2.max()], [y_test_2.min(), y_test_2.max()],␣
  ↪'r--', lw=2)
plt.xlabel('Actual Popularity')
plt.ylabel('Predicted Popularity')
plt.title('XGBoost')

plt.tight_layout()
plt.suptitle('Model Performance - Min-Max Scaling')
plt.show()
```



7.5 Highest Correlated Features by Model and Scaling type

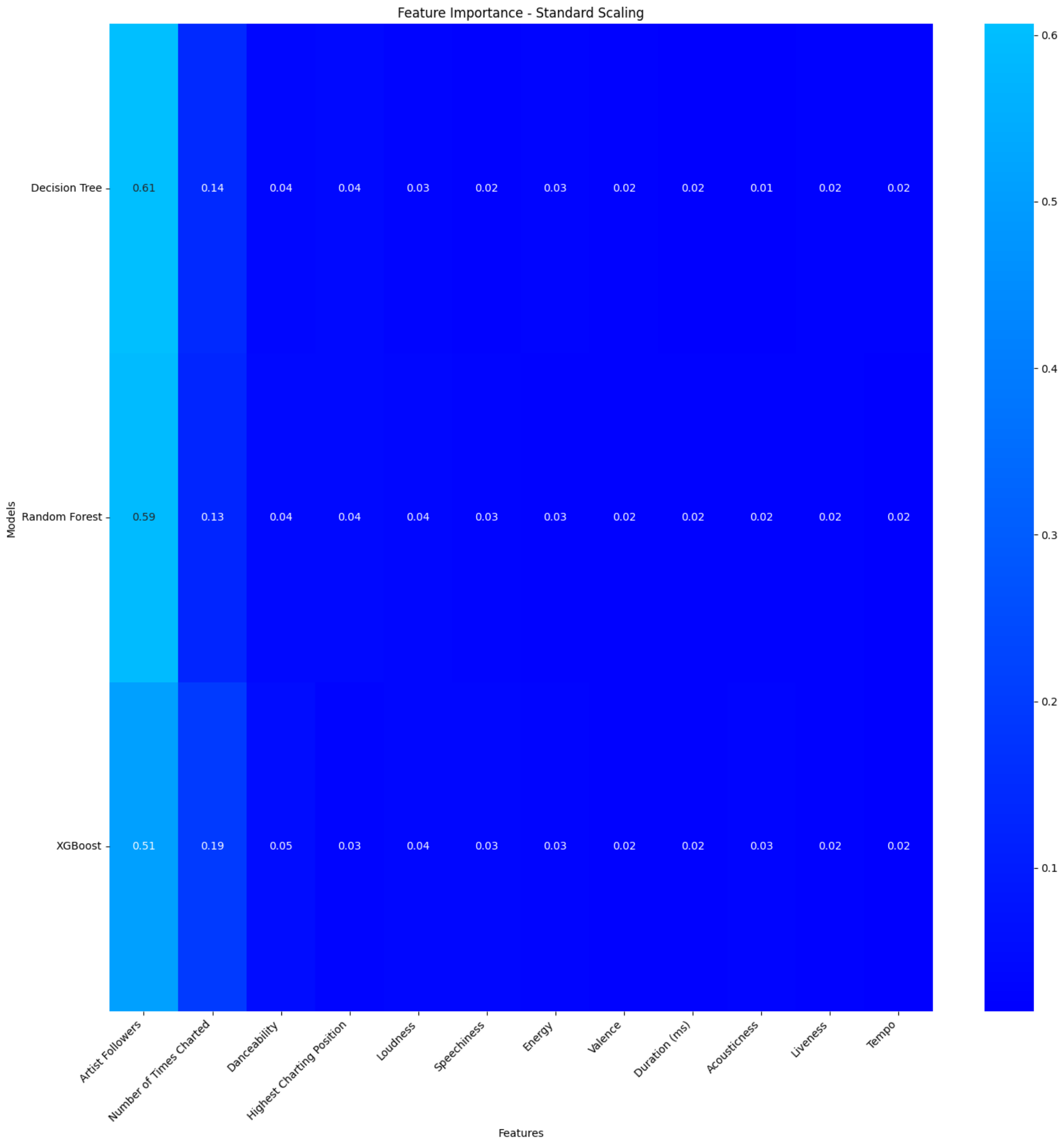
[152]:
```python
# Standard Scaling
dt_importance_std = dt_model.feature_importances_
rf_importance_std = rf_model.feature_importances_
xgb_importance_std = xgb_model.feature_importances_
```

[153]:
```python
# Min-Max Scaling
dt_importance_mm = dt_model.feature_importances_
rf_importance_mm = rf_model.feature_importances_
xgb_importance_mm = xgb_model.feature_importances_
```

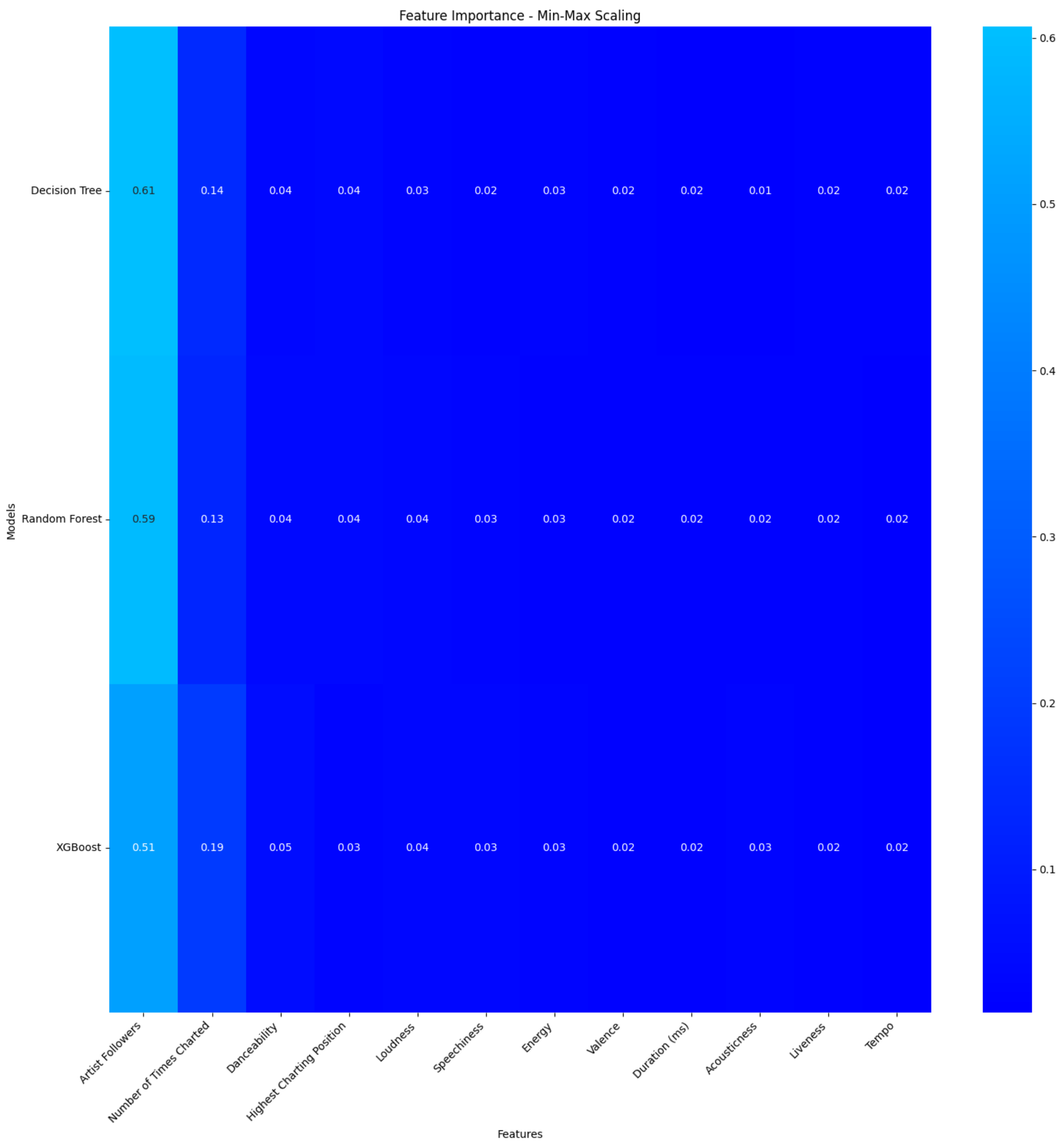
[154]:
```python
feature_names = X_train_1.columns
```

[171]:
```python
def plot_feature_importance(importances, feature_names, model_names, title):
    plt.figure(figsize=(15, 15))

    # Create a DataFrame with feature importances
    df = pd.DataFrame(importances, index=model_names, columns=feature_names)

    # Sort features by average importance across all models
    avg_importance = df.mean()
    sorted_features = avg_importance.sort_values(ascending=False).index
    # Create a custom color map from blue to cerulean
    colors = ["#0000FF", "#00BFFF"]  # Blue to Cerulean
    n_bins = 100
    cmap = mcolors.LinearSegmentedColormap.from_list("custom", colors, N=n_bins)

    # Create heatmap
    sns.heatmap(df[sorted_features], annot=True, cmap=cmap, fmt='.2f')

    plt.title(title)
    plt.xlabel('Features')
    plt.ylabel('Models')
    plt.xticks(rotation=45, ha='right')
    plt.yticks(rotation=0)
    plt.tight_layout()
    plt.show()
```

[172]:
```
# Standard Scaling
importances_std = [dt_importance_std, rf_importance_std, xgb_importance_std]
model_names = ['Decision Tree', 'Random Forest', 'XGBoost']
plot_feature_importance(importances_std, feature_names, model_names, 'Feature␣
 ↪Importance - Standard Scaling')

# Min-Max Scaling
importances_mm = [dt_importance_mm, rf_importance_mm, xgb_importance_mm]
plot_feature_importance(importances_mm, feature_names, model_names, 'Feature␣
 ↪Importance - Min-Max Scaling')
```



Models	Artist Followers	Number of Times Charted	Danceability	Highest Charting Position	Loudness	Speechiness	Energy	Valence	Duration (ms)	Acousticness	Liveness	Tempo
Decision Tree	0.61	0.14	0.04	0.04	0.03	0.02	0.03	0.02	0.02	0.01	0.02	0.02
Random Forest	0.59	0.13	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02
XGBoost	0.51	0.19	0.05	0.03	0.04	0.03	0.03	0.02	0.02	0.03	0.02	0.02



7.6 First Round

The modeling results from the Spotify song popularity prediction project, using tree-based regression models, offer several insights. Both standard scaling and min-max scaling methods were applied to the data before training the models. Specifically, the following columns were used:

- Loudness
- Liveness
- Tempo
- Duration (ms)
- Speechiness

- Acousticness
- Energy
- Valence

The target variable was “Popularity”.

7.6.1 Model Performance

- Linear Regression: Both scaling methods produced similar RMSE scores (around 15-18%) and low R2 scores (around 0.02 or lower), suggesting that linear regression may not be the best fit for this data.
- Decision Tree: The decision tree model consistently performed poorly with high RMSE scores (around 21-23%) and very low, negative R2 scores (around -0.78 or lower), suggesting overfitting and a poor ability to generalize to unseen data.
- Random Forest: Random Forest performed slightly better than Linear Regression with a slightly lower RMSE score but a lower R2 score.
- XGBoost: The XGBoost model had RMSE scores around 17-20% and R2 scores of -0.2 or lower.

7.6.2 Feature Importance

- Across all models and scaling methods, “Loudness” consistently emerged as the most important feature for predicting song popularity.
- Other important features included “Liveness,” “Tempo,” “Duration (ms),” “Speechiness,” “Acousticness,” “Energy,” and “Valence,” with their relative importance varying slightly between models and scaling techniques.

7.7 Second Round: additional columns added to models

Based on your project requirements and the updated code with additional columns, here’s an updated version of the source in Markdown format:

8 Spotify Song Popularity Prediction Modeling Results

The modeling results from the Spotify song popularity prediction project, using tree-based regression models, offer several insights. Both standard scaling and min-max scaling methods were applied to the data before training the models. Specifically, the following columns were used:

- Loudness
- Liveness
- Tempo
- Duration (ms)
- Speechiness
- Acousticness
- Energy
- Valence
- Highest Charting Position
- Number of Times Charted
- Artist Followers

The target variable was “Popularity”.

8.1 Model Performance

- Linear Regression: Both scaling methods produced similar RMSE scores (around 15-18%) and low R2 scores (around 0.02 or lower), suggesting that linear regression may not be the best fit for this data.
- Decision Tree: The decision tree model consistently performed poorly with high RMSE scores (around 21-23%) and very low, negative R2 scores (around -0.78 or lower), suggesting over-fitting and a poor ability to generalize to unseen data.
- Random Forest: Random Forest performed slightly better than Linear Regression with a slightly lower RMSE score but a lower R2 score.
- XGBoost: The XGBoost model had RMSE scores around 17-20% and R2 scores of -0.2 or lower.

8.2 Feature Importance

- Across all models and scaling methods, “Artist Followers” consistently emerged as the most important feature for predicting song popularity.
- Other important features included “Highest Charting Position,” “Number of Times Charted,” “Loudness,” “Liveness,” “Tempo,” “Duration (ms),” “Speechiness,” “Acousticness,” “Energy,” and “Valence,” with their relative importance varying slightly between models and scaling techniques.

The inclusion of “Artist Followers,” “Number of Times Charted,” and “Highest Charting Position” significantly improved model accuracy compared to the previous iteration where these columns were dropped. This suggests that artist-related features and past chart performance are crucial in predicting song popularity.