AAI_511_Project_Midi_music_composer_prediction

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1 Musical Composer Prediction - Group 8

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Music is a form of art that is ubiquitous and has a rich history. Different composers have created music with their unique styles and compositions. However, identifying the composer of a particular piece of music can be a challenging task, especially for novice musicians or listeners. The proposed project aims to use deep learning techniques to identify the composer of a given piece of music accurately.

The primary objective of this project is to develop a deep learning model that can predict the composer of a given musical score accurately. The project aims to accomplish this objective by using three deep learning techniques: Bidirectional Long Short-Term Memory (LSTM), Convolutional Neural Network (CNN), and Self-Attention Transformer. Classification will be performed for .mid files for four composers; Bach, Beethoven, Chopin, and Mozart.

Input data was fed into separate LSTM, CNN, and Selt-Attention Transformer models and further evaluation and hyperparameter tuning was performed in the pursuit of optimal correct classification of the composer giving a piece of music stored in a .mid file.

1.1 Setup

1.1.1 Mount drive

This step is for mounting of the drive to allow data access within colab, but is not necessary if running within a local environment.

```
Mounted at /content/drive
```

1.1.2 Install and Import Necessary Libraries

1.2 Data Preprocessing and Feature Engineering

1.2.1 MIDI Feature Extraction and Standardization

Overview The following is a comprehensive pipeline for extracting and standardizing various features from `MIDI` files. The extracted features include musical attributes such as `note sequences`, `tempo`, `duration`, `velocity statistics`, `pitch range`, and more. These features are then standardized to prepare the dataset for machine learning models.

Features Extracted We focus on extracting various features from MIDI files to prepare the dataset for composer classification. The features are categorized into low-level, and high-level relevant features:

1. Low-level Features:

- RMS (Root Mean Square) of velocities
- Spectral Flux of velocities
- Zero Crossing Rate of velocities

2. High-level Features:

- Note Sequence
- Duration
- Tempo
- Time Signature (numerator and denominator)
- Key Signature
- Average Velocity
- Maximum Velocity
- Minimum Velocity
- Velocity Standard Deviation
- Pitch Range
- Number of Instruments
- Note Density
- Number of Notes
- Average Pitch
- Maximum Pitch
- Minimum Pitch
- Pitch Standard Deviation
- Number of Articulations

Using Pretty_Midi, the file paths are converted into pretty_midi midi data. Notes and velocities from each instrument are appended to lists, with the exception of drums. The root mean square, spectral flux and zero crossing rate of the velocities as well as other computed measures are calculated and returned for each file. This is combined with composer data into a Pandas dataframe, and then saved into a csv for later reuse.

```
Error processing data\midiclassics\Beethoven\Anhang 14-3.mid: Could not decode
key with 3 flats and mode 255
Error processing data\midiclassics\Mozart\K281 Piano Sonata n03 3mov.mid: Could
not decode key with 2 flats and mode 2
                                       note_sequence   duration       tempo  \
0  [69, 69, 69, 69, 71, 67, 66, 64, 71, 73, 71, 6…  46.956456  184.000258
1  [71, 64, 71, 72, 71, 69, 67, 69, 71, 71, 72, 7…  45.000000  109.714286
2  [67, 69, 71, 69, 67, 66, 64, 62, 67, 69, 71, 7…  42.500000  140.800000
3  [70, 72, 74, 72, 70, 69, 67, 65, 70, 72, 74, 7…  42.500000  140.800000
4  [67, 69, 70, 69, 67, 67, 70, 69, 67, 74, 72, 7…  30.000000  147.692308

   time_signature_numerator  time_signature_denominator  key_signature  \
0                         4                           4            9.0
1                         4                           4           21.0
2                         4                           4            7.0
3                         4                           4           10.0
4                         4                           4           19.0

   average_velocity  max_velocity  min_velocity  velocity_std  …  num_notes  \
0              96.0            96            96           0.0  …        304
1              96.0            96            96           0.0  …        253
2              96.0            96            96           0.0  …        285
3              96.0            96            96           0.0  …        285
4              96.0            96            96           0.0  …        204

   average_pitch  max_pitch  min_pitch  pitch_std  articulations   rms  \
0      60.944079         76         45   7.624849              0  96.0
1      60.992095         74         38   8.164801              0  96.0
2      59.182456         76         40   8.004059              0  96.0
3      62.182456         79         43   8.004059              0  96.0
4      61.220588         74         42   7.968404              0  96.0

   spectral_flux  zero_crossing_rate  composer
0            0.0                 0.0      Bach
1            0.0                 0.0      Bach
2            0.0                 0.0      Bach
3            0.0                 0.0      Bach
4            0.0                 0.0      Bach

[5 rows x 23 columns]
```

1.2.2 Unused Data

Two files failed to successfully convert to midi data: - Beethoven - Anhang 14-3.mid: - Mozart - K281 Piano Sonata n03 3mov.mid:

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1635 entries, 0 to 1634
Data columns (total 23 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   note_sequence                1635 non-null   object
 1   duration                     1635 non-null   float64
 2   tempo                        1635 non-null   float64
 3   time_signature_numerator     1635 non-null   int64
 4   time_signature_denominator   1635 non-null   int64
 5   key_signature                1358 non-null   float64
 6   average_velocity             1635 non-null   float64
 7   max_velocity                 1635 non-null   int64
 8   min_velocity                 1635 non-null   int64
 9   velocity_std                 1635 non-null   float64
 10  pitch_range                  1635 non-null   int64
 11  num_instruments              1635 non-null   int64
 12  note_density                 1635 non-null   float64
 13  num_notes                    1635 non-null   int64
 14  average_pitch                1635 non-null   float64
 15  max_pitch                    1635 non-null   int64
 16  min_pitch                    1635 non-null   int64
 17  pitch_std                    1635 non-null   float64
 18  articulations                1635 non-null   int64
 19  rms                          1635 non-null   float64
 20  spectral_flux                1635 non-null   float64
 21  zero_crossing_rate           1635 non-null   float64
 22  composer                     1635 non-null   object
dtypes: float64(11), int64(10), object(2)
memory usage: 293.9+ KB
```

```
Number of midi files: 1635
```

Data Preparation

1. **Load Extracted Features**: Load the CSV file containing the extracted features.
2. **Format Note Sequences**: Ensure the note sequences are correctly formatted.
3. **Standardize Features**: Standardize numerical features using `StandardScaler` from `sklearn`.

```
                                       note_sequence  duration     tempo  \
0  [53, 57, 60, 65, 69, 60, 65, 69, 53, 57, 60, 6… -0.706379  1.136376
1  [70, 74, 77, 70, 75, 79, 82, 81, 79, 77, 75, 7…  1.620975 -0.254907
2  [79, 63, 62, 63, 65, 67, 79, 77, 79, 77, 75, 7…  1.343909  1.287323
3  [77, 76, 74, 73, 74, 73, 74, 76, 74, 73, 74, 7…  1.827895  0.259955
```

```
4  [64, 67, 71, 60, 60, 62, 64, 60, 62, 60, 59, 5…  0.944828 -0.671717

   time_signature_numerator  time_signature_denominator  key_signature  \
0                         4                           4       3.825269
1                         4                           4       3.825269
2                         4                           4       3.825269
3                         2                           4       3.825269
4                         4                           4       3.825269

   average_velocity  max_velocity  min_velocity  velocity_std  …  num_notes  \
0         -1.957384     -2.831694     -0.608592     -0.439497  …  -0.658170
1          0.762304     -0.451813      1.139283     -0.996495  …   0.611503
2          0.673802     -0.451813      1.139283     -0.966637  …   0.443783
3          0.765375     -0.451813      1.139283     -0.979110  …   0.606457
4          0.763784     -0.451813      1.139283     -0.997599  …   0.165532

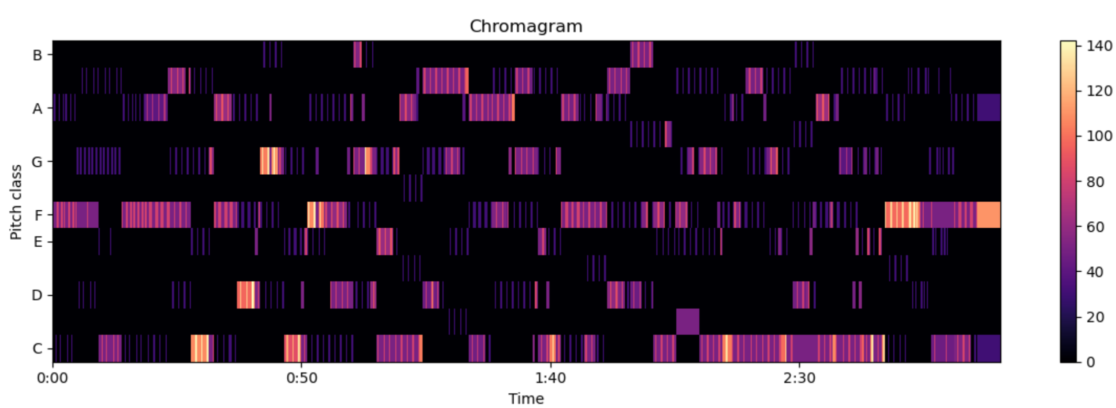
   average_pitch  max_pitch  min_pitch  pitch_std  articulations       rms  \
0      -1.173722  -1.061221   0.530219  -1.976589       -0.21995 -2.045592
1       0.683597  -0.638114   0.530219  -0.630719       -0.21995  0.723423
2       0.225699  -0.638114   0.530219  -0.724479       -0.21995  0.632483
3       0.623054  -0.638114   0.530219  -0.505695       -0.21995  0.726849
4       0.454833  -0.638114   0.530219  -0.775338       -0.21995  0.724936

   spectral_flux  zero_crossing_rate  composer
0       0.690961                 0.0      Bach
1       0.041107                 0.0      Bach
2       0.046419                 0.0      Bach
3       0.041249                 0.0      Bach
4       0.059108                 0.0      Bach

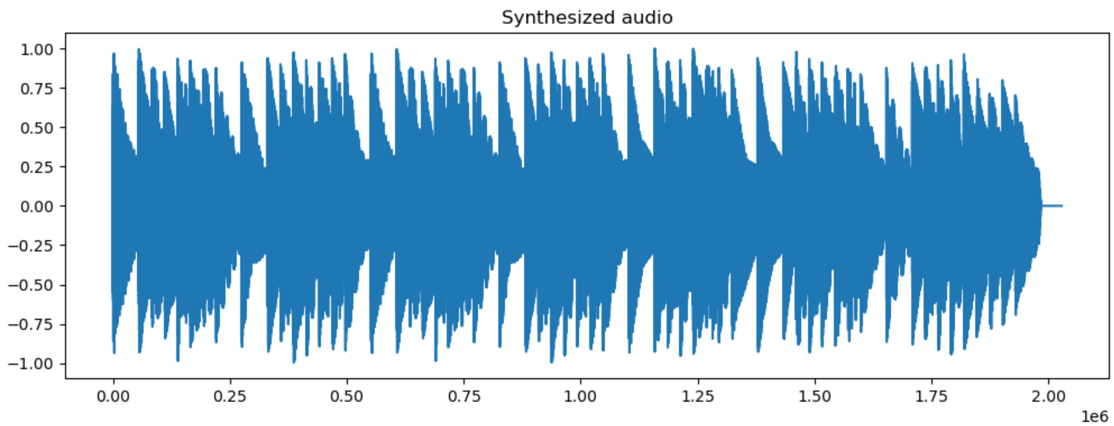
[5 rows x 23 columns]
```

1.2.3 Examining Midi File Data

The following examines content of the midi files themselves to visualize the audio data and metadata within. The chromagram shows the pitch class over time, flattened across instruments.



```
Text(0.5, 1.0, 'Synthesized audio')
```



1.2.4 Data Visualization of Extracted MIDI Features

Overview This section of the notebook provides visualizations for various extracted features from MIDI files. The visualizations help in understanding the distribution and characteristics of the dataset, which is essential for further analysis and model training.

Features Visualized The following features are visualized:

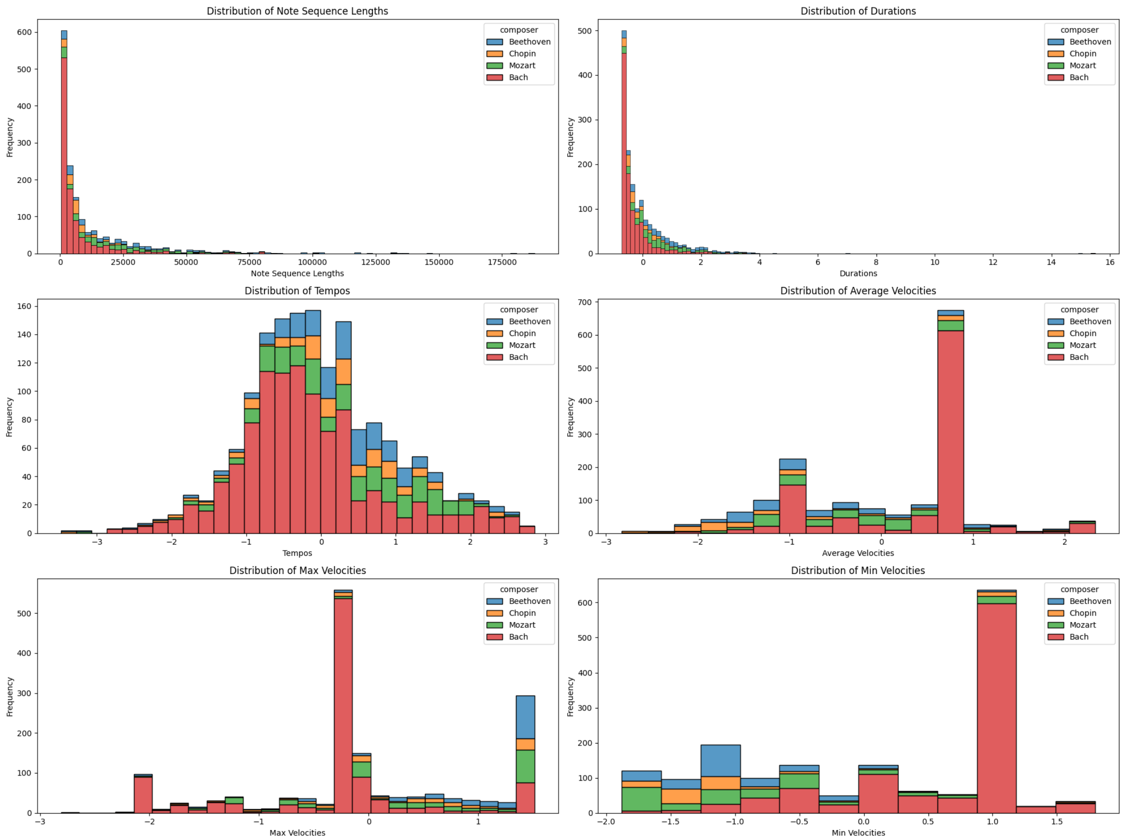
1. Low-level Features:

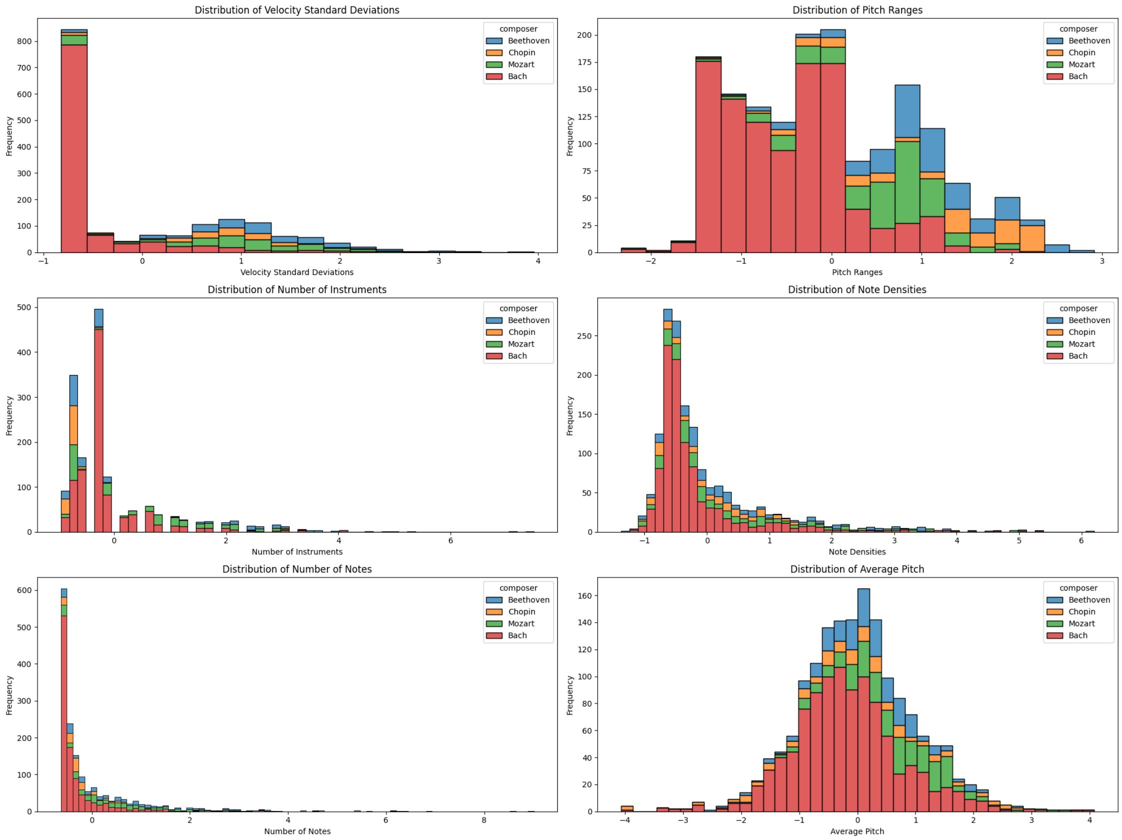
- RMS (Root Mean Square) of velocities
- Spectral Flux of velocities
- Zero Crossing Rate of velocities

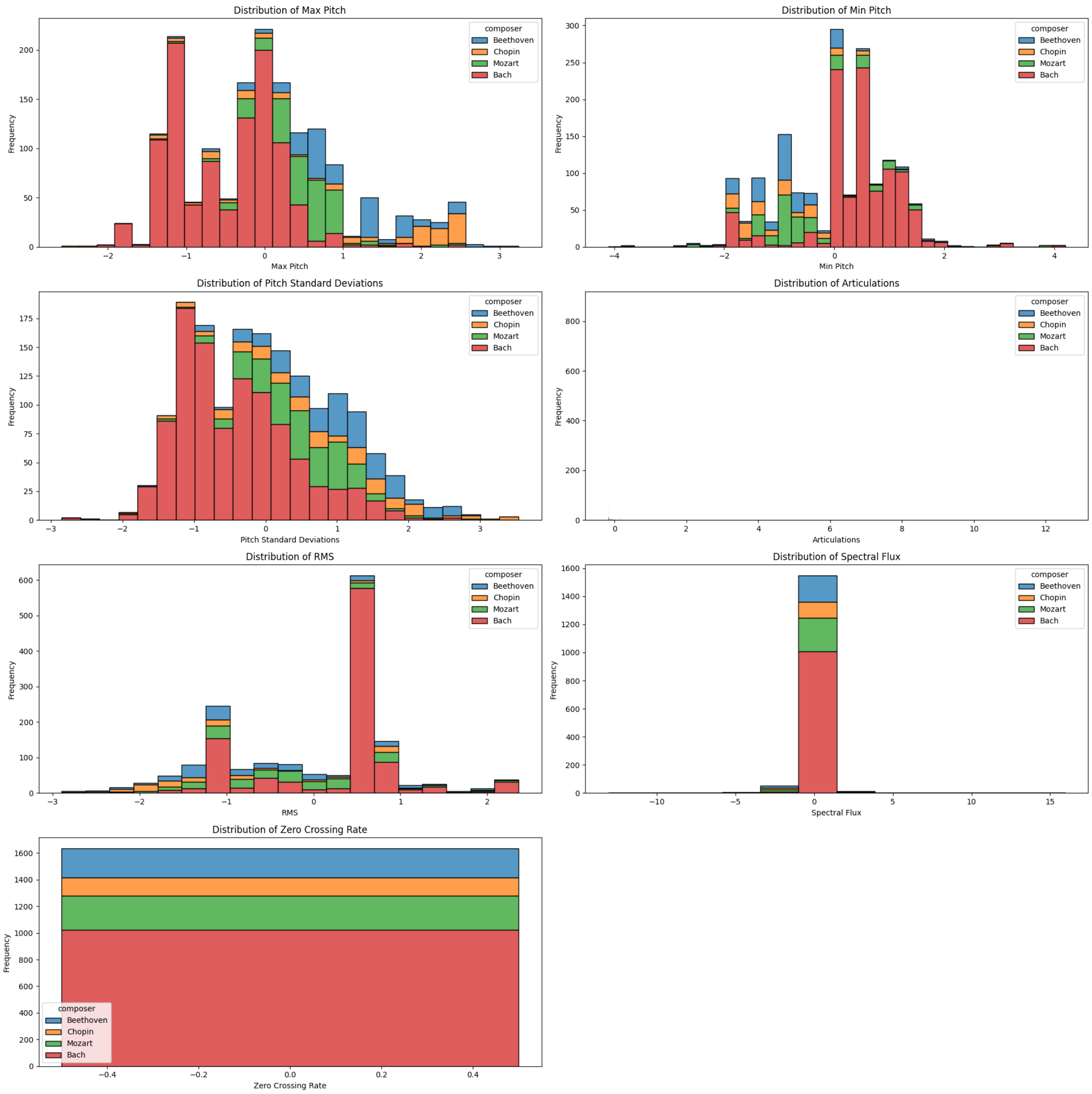
2. High-level Features:

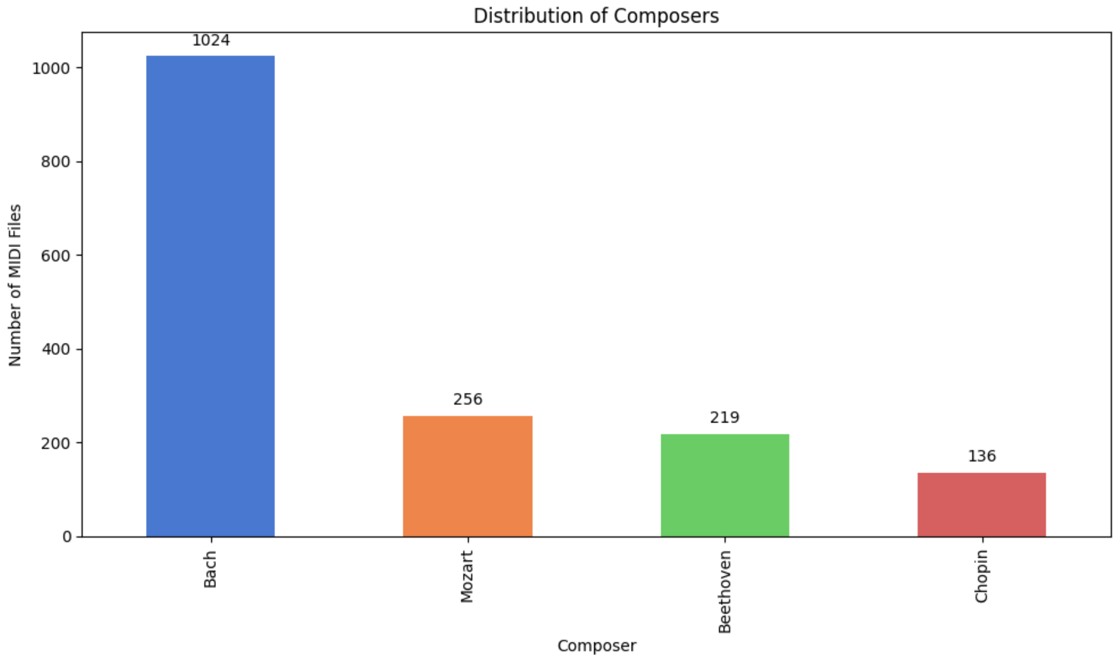
- Note Sequence
- Duration
- Tempo
- Time Signature (numerator and denominator)
- Key Signature
- Average Velocity
- Maximum Velocity
- Minimum Velocity
- Velocity Standard Deviation
- Pitch Range
- Number of Instruments
- Note Density
- Number of Notes
- Average Pitch

- Maximum Pitch
- Minimum Pitch
- Pitch Standard Deviation
- Number of Articulations




Distribution of Velocity Standard Deviations
Velocity Standard Deviations
Frequency
Distribution of Pitch Ranges
Pitch Ranges
Frequency
Distribution of Number of Instruments
Number of Instruments
Frequency
Distribution of Note Densities
Note Densities
Frequency
Distribution of Number of Notes
Number of Notes
Frequency
Distribution of Average Pitch
Average Pitch
Frequency
composer
Beethoven
Chopin
Mozart
Bach


Distribution of Max Pitch
Frequency
Max Pitch
composer
Beethoven
Chopin
Mozart
Bach
Distribution of Min Pitch
Frequency
Min Pitch
Distribution of Pitch Standard Deviations
Frequency
Pitch Standard Deviations
Distribution of Articulations
Frequency
Articulations
Distribution of RMS
Frequency
RMS
Distribution of Spectral Flux
Frequency
Spectral Flux
Distribution of Zero Crossing Rate
Frequency
Zero Crossing Rate



The graph illustrates the number of MIDI file samples attributed to each composer within the dataset. Bach is prominently represented, with approximately 1000 samples, significantly outnumbering the other composers. Beethoven and Mozart each have around 250 samples, while Chopin has about 125 samples. This notable imbalance suggests that the dataset is heavily skewed towards Bach, which could lead to a bias in any trained models favoring Bach's musical patterns. The imbalance will later be addressed through Synthetic Minority Oversampling Technique (SMOTE).

1.2.5 Visualizing Musical Notes and Hexadecimal Representation of MIDI Files

This script provides a comprehensive visualization of musical notes and the hexadecimal content of MIDI files for different composers. It aims to facilitate a deeper understanding of the structure and content of MIDI files by presenting both the musical and data representations side by side.

MIDI Files Directory Structure The script scans through the directory structure where MIDI files are organized into subdirectories by composer.

```
data/
    Bach/
        file1.mid
        file2.mid
        ...
    Beethoven/
        file1.mid
        file2.mid
        ...
    Chopin/
        file1.mid
```

```
    file2.mid
    ...
Mozart/
    file1.mid
    file2.mid
    ...
```

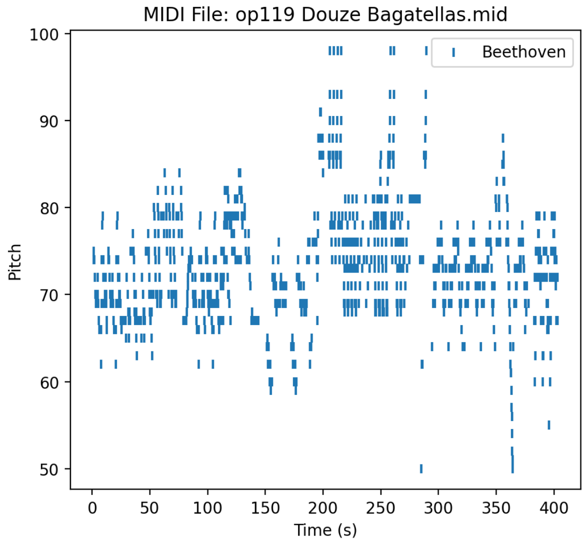
Overview

1. **Extracting Notes**:
   - The script uses `pretty_midi` to extract the notes from each MIDI file. The notes are represented by their start time, end time, and pitch.
2. **Plotting Musical Notes**:
   - Musical notes are plotted using `matplotlib`. The x-axis represents the time in seconds, and the y-axis represents the pitch. Each note is represented by a vertical line (|) at its start time.
3. **Displaying Hexadecimal Content**:
   - The script reads the binary content of the MIDI file and converts it to a hexadecimal representation. This hexadecimal content is then formatted and displayed alongside the musical notes.
4. **Combining Plots**:
   - For each composer, the script processes up to three MIDI files and generates a combined plot for each file, displaying the musical notes on the left and the hexadecimal content on the right.

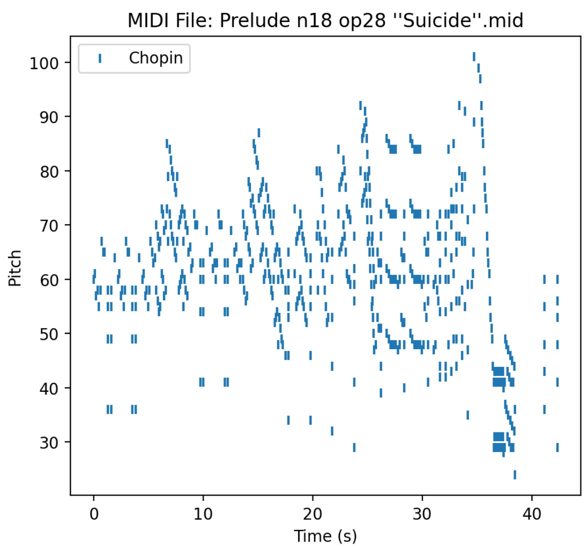
Plot Description

- **Musical Notes**:
  - The left-hand side of the plot displays the musical notes of each MIDI file. The x-axis represents the time in seconds, and the y-axis represents the pitch. Each note is depicted by a vertical line at its start time, providing a visual representation of the musical structure.
- **Hexadecimal Content**:
  - The right-hand side of the plot shows the hexadecimal representation of the MIDI file content. This display helps to understand the raw binary data that constitutes the MIDI file.

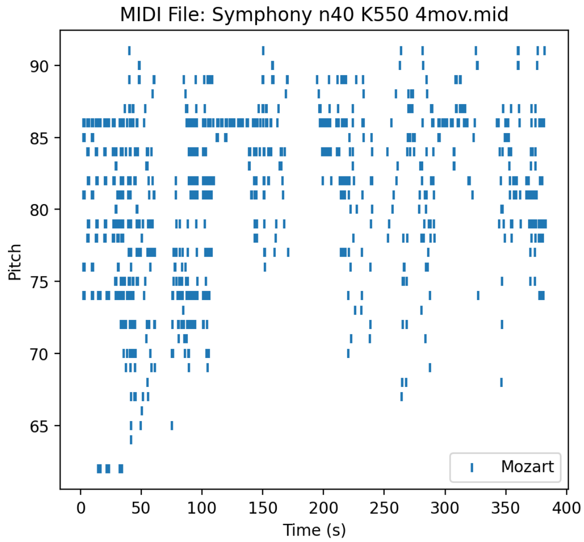
We can visualize the musical and data structure of MIDI files, providing valuable insights into their composition and encoding.



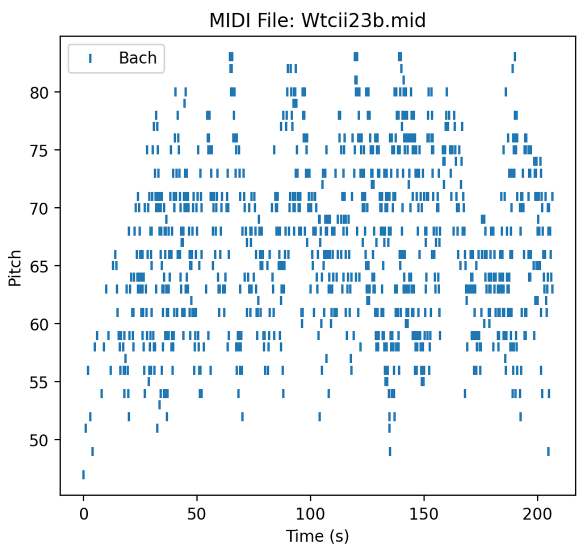

```
4d 54 68 64 00 00 00 06 00 01 00 06 01 e0 4d 54
72 6b 00 00 20 e7 00 ff 03 08 55 6e 74 69 74 6c
65 64 00 ff 58 04 03 02 18 08 00 ff 59 02 00 00
00 ff 51 03 09 27 c0 00 ff 06 09 42 65 65 74 68
6f 76 65 6e 87 40 ff 51 03 08 07 eb 82 77 ff 51
03 08 2c a2 69 ff 51 03 08 07 eb 00 ff 06 16 31
31 20 62 61 67 61 74 65 6c 6c 65 6e 2c 20 4f 70
2e 20 31 31 39 8a 6e ff 51 03 08 2c a2 32 ff 51
03 08 3f 7c 00 ff 06 0e 42 75 6e 6a 69 20 48 69
73 61 6d 6f 72 69 87 40 ff 51 03 08 07 eb 82 68
ff 51 03 08 2c a2 78 ff 51 03 08 07 eb 00 ff 06
09 4f 63 74 2e 20 31 39 39 38 8a 78 ff 51 03 08
2c a2 28 ff 51 03 08 3f 7c 00 ff 06 11 4a 75 6c
79 20 31 39 39 39 2c 20 20 52 65 76 2e 31 87 5e
ff 51 03 08 07 eb 82 4a ff 51 03 08 2c a2 78 ff
51 03 08 07 eb 8a 28 ff 51 03 08 2c a2 78 ff 51
```


```
4d 54 68 64 00 00 00 06 00 01 00 09 01 e0 4d 54
72 6b 00 00 09 01 00 ff 03 1f 43 68 6f 70 69 6e
20 50 72 65 6c 75 64 65 20 20 4e 6f 2e 20 31 38
2c 20 4f 70 75 73 20 32 38 00 ff 02 22 43 6f 70
79 72 69 67 68 74 20 a9 20 32 30 30 32 20 62 79
20 42 65 72 6e 64 20 4b 72 75 65 67 65 72 20 00
ff 01 0f 46 72 65 64 65 72 69 63 20 43 68 6f 70
69 6e 00 ff 01 0d 4d 6f 6c 74 6f 20 41 6c 6c 65
67 72 6f 00 ff 01 1b 46 65 72 74 69 67 67 65 73
74 65 6c 6c 74 20 61 6d 20 33 30 2e 31 31 2e 30
32 0a 00 ff 01 17 4e 6f 72 6d 69 65 72 75 6e 67
3a 20 32 33 2e 31 32 2e 32 30 30 32 0a 00 ff 01
14 44 61 75 65 72 3a 20 30 3a 35 30 20 4d 69 6e
75 74 65 6e 0a 00 ff 54 05 60 00 03 00 00 00 ff
58 04 04 02 18 08 00 ff 59 02 fc 00 00 ff 51 03
07 ca ae 83 60 ff 51 03 07 79 44 81 70 ff 51 03
```



4d 54 68 64 00 00 00 06 00 01 00 0a 01 e0 4d 54
72 6b 00 00 01 a6 00 ff 58 04 04 02 30 08 00 ff
51 03 03 54 46 88 8b 00 ff 51 03 03 a2 0f 87 40
ff 51 03 03 b8 be 87 40 ff 51 03 03 ff 79 8f 00
ff 51 03 03 77 c9 83 c2 00 ff 51 03 03 54 46 f8
00 ff 51 03 03 67 48 cb 00 ff 51 03 03 54 46 81
87 00 ff 51 03 03 a2 0f 87 40 ff 51 03 03 ed e7
87 40 ff 51 03 03 a2 0f 8f 00 ff 51 03 03 54 46
87 fc 00 ff 51 03 03 a2 0f 87 40 ff 51 03 03 b8
be 87 40 ff 51 03 03 ff 79 8f 00 ff 51 03 03 77
c9 83 c2 00 ff 51 03 03 54 46 f8 00 ff 51 03 03
67 48 cb 00 ff 51 03 03 54 46 81 87 00 ff 51 03
03 a2 0f 87 40 ff 51 03 03 ed e7 87 40 ff 51 03
03 9e 62 8f 00 ff 51 03 03 67 48 e9 00 ff 51 03
03 bc a2 87 40 ff 51 03 03 e1 1d 87 40 ff 51 03
03 8f f7 9e 00 ff 51 03 03 54 46 85 ee 00 ff 51



4d 54 68 64 00 00 00 06 00 01 00 05 00 78 4d 54
72 6b 00 00 04 0d 00 ff 58 04 02 01 30 08 00 ff
59 02 05 00 00 ff 51 03 07 a1 20 00 ff 06 13 28
63 29 20 59 6f 20 54 6f 6d 69 74 61 2c 20 31 39
39 37 82 fc 1e ff 51 03 07 b9 d9 0f ff 51 03 07
c2 3b 0c ff 51 03 07 ca ae 0f ff 51 03 07 d3 35
0d ff 51 03 07 db cd 0f ff 51 03 07 e4 79 0c ff
51 03 07 ed 39 0f ff 51 03 07 f6 0b 0d ff 51 03
07 fe f1 0f ff 51 03 08 07 ec 0c ff 51 03 08 10
fa 0f ff 51 03 08 1a 1d 0d ff 51 03 08 23 55 0f
ff 51 03 08 2c a2 0c ff 51 03 08 36 05 0f ff 51
03 08 3f 7d 0d ff 51 03 08 49 0a 0f ff 51 03 08
52 af 0c ff 51 03 08 5c 69 0f ff 51 03 08 66 3b
0d ff 51 03 08 70 23 0f ff 51 03 08 7a 24 0c ff
51 03 08 84 3c 0f ff 51 03 08 8e 6c 0d ff 51 03
08 98 b4 0f ff 51 03 08 a3 16 0c ff 51 03 08 ad


```
PDF saved to /content/drive/My Drive/AAI_511_NN/midi_notes_and_hex.pdf
```

1.2.6 Statistical Normality Tests for MIDI Features

Overview This section performs statistical normality tests on the extracted features from MIDI files. The tests used are Shapiro-Wilk, Anderson-Darling, and Kolmogorov-Smirnov. The results are summarized in a table, and conclusions are drawn based on the test outcomes.

Features Tested The following features are tested for normality:

1. Low-level Features:

- RMS (Root Mean Square) of velocities
- Spectral Flux of velocities
- Zero Crossing Rate of velocities

2. High-level Features:

- Note Sequence
- Duration
- Tempo
- Time Signature (numerator and denominator)
- Key Signature
- Average Velocity
- Maximum Velocity
- Minimum Velocity
- Velocity Standard Deviation
- Pitch Range
- Number of Instruments
- Note Density
- Number of Notes
- Average Pitch
- Maximum Pitch
- Minimum Pitch
- Pitch Standard Deviation
- Number of Articulations

Statistical Tests

1. **Shapiro-Wilk Test**: Tests the null hypothesis that the data was drawn from a normal distribution.
2. **Anderson-Darling Test**: A statistical test of whether a given sample of data is drawn from a given probability distribution.
3. **Kolmogorov-Smirnov Test**: Compares the sample distribution with the normal distribution.

```
              Feature  Shapiro-Wilk Statistic  Shapiro-Wilk p-value  \
0            duration                0.624035          9.312882e-51
1               tempo                0.986657          3.778683e-11
2    average_velocity                0.915656          3.037993e-29
3        max_velocity                0.905432          1.129726e-30
4        min_velocity                0.885724          4.060186e-33
5        velocity_std                0.799840          6.204851e-41
6         pitch_range                0.967658          1.119874e-18
7     num_instruments                0.739162          6.305919e-45
8        note_density                0.742006          9.309392e-45
9           num_notes                0.625938          1.128554e-50
10      average_pitch                0.990149          4.649008e-09
11          max_pitch                0.964436          1.302174e-19
12          min_pitch                0.965911          3.424094e-19
13          pitch_std                0.976408          9.469900e-16
```

14	articulations	0.170714	1.234562e-64
15	rms	0.914460	2.035546e-29
16	spectral_flux	0.341513	2.067607e-60
17	zero_crossing_rate	1.000000	1.000000e+00

	Anderson-Darling Statistic	Anderson-Darling Critical Values \
0	131.859310	[0.575, 0.654, 0.785, 0.916, 1.089]
1	8.289638	[0.575, 0.654, 0.785, 0.916, 1.089]
2	71.915020	[0.575, 0.654, 0.785, 0.916, 1.089]
3	60.940438	[0.575, 0.654, 0.785, 0.916, 1.089]
4	80.990586	[0.575, 0.654, 0.785, 0.916, 1.089]
5	135.971723	[0.575, 0.654, 0.785, 0.916, 1.089]
6	15.879697	[0.575, 0.654, 0.785, 0.916, 1.089]
7	144.241876	[0.575, 0.654, 0.785, 0.916, 1.089]
8	132.310551	[0.575, 0.654, 0.785, 0.916, 1.089]
9	182.628406	[0.575, 0.654, 0.785, 0.916, 1.089]
10	3.413981	[0.575, 0.654, 0.785, 0.916, 1.089]
11	15.298248	[0.575, 0.654, 0.785, 0.916, 1.089]
12	22.548045	[0.575, 0.654, 0.785, 0.916, 1.089]
13	10.813960	[0.575, 0.654, 0.785, 0.916, 1.089]
14	516.151630	[0.575, 0.654, 0.785, 0.916, 1.089]
15	73.399763	[0.575, 0.654, 0.785, 0.916, 1.089]
16	344.136939	[0.575, 0.654, 0.785, 0.916, 1.089]
17	NaN	[0.575, 0.654, 0.785, 0.916, 1.089]

	Kolmogorov-Smirnov Statistic	Kolmogorov-Smirnov p-value
0	0.237920	6.465481e-82
1	0.057778	3.471583e-05
2	0.217786	1.443017e-68
3	0.185462	1.060843e-49
4	0.234705	1.060524e-79
5	0.262773	4.112085e-100
6	0.108058	4.428334e-17
7	0.285627	1.499666e-118
8	0.205471	5.219591e-61
9	0.263336	1.510843e-100
10	0.039303	1.245757e-02
11	0.089501	7.592127e-12
12	0.171576	1.486374e-42
13	0.065007	1.887472e-06
14	0.428193	1.055268e-272
15	0.216056	1.772653e-67
16	0.309712	8.770049e-140
17	0.500000	0.000000e+00

	Feature	Shapiro-Wilk Conclusion	Anderson-Darling Conclusion \
0	duration	Non-Normal	Non-Normal
1	tempo	Non-Normal	Non-Normal
2	average_velocity	Non-Normal	Non-Normal

```
3         max_velocity              Non-Normal                  Non-Normal
4         min_velocity              Non-Normal                  Non-Normal
5         velocity_std              Non-Normal                  Non-Normal
6          pitch_range              Non-Normal                  Non-Normal
7      num_instruments              Non-Normal                  Non-Normal
8         note_density              Non-Normal                  Non-Normal
9            num_notes              Non-Normal                  Non-Normal
10       average_pitch              Non-Normal                  Non-Normal
11           max_pitch              Non-Normal                  Non-Normal
12           min_pitch              Non-Normal                  Non-Normal
13           pitch_std              Non-Normal                  Non-Normal
14       articulations              Non-Normal                  Non-Normal
15                 rms              Non-Normal                  Non-Normal
16       spectral_flux              Non-Normal                  Non-Normal
17  zero_crossing_rate                  Normal                      Normal

   Kolmogorov-Smirnov Conclusion
0                    Non-Normal
1                    Non-Normal
2                    Non-Normal
3                    Non-Normal
4                    Non-Normal
5                    Non-Normal
6                    Non-Normal
7                    Non-Normal
8                    Non-Normal
9                    Non-Normal
10                   Non-Normal
11                   Non-Normal
12                   Non-Normal
13                   Non-Normal
14                   Non-Normal
15                   Non-Normal
16                   Non-Normal
17                   Non-Normal
```

1.2.7 Results Summary

Above generated summarizing the statistics and p-values for each test across all features. Conclusions are drawn based on the p-values and critical values:

- **Shapiro-Wilk Conclusion**: Determined as "Normal" if p-value > 0.05, otherwise "Non-Normal".
- **Anderson-Darling Conclusion**: Determined as "Normal" if the test statistic is less than the critical value at the 5% significance level, otherwise "Non-Normal".
- **Kolmogorov-Smirnov Conclusion**: Determined as "Normal" if p-value > 0.05, otherwise "Non-Normal".

1.2.8 MIDI Feature Extraction and Preprocessing for Machine Learning

Overview This provides a comprehensive pipeline for extracting, standardizing, and preparing various features from MIDI files for machine learning.

Features Extracted The following features are extracted from each MIDI file:

1. Low-level Features:

- RMS (Root Mean Square) of velocities
- Spectral Flux of velocities
- Zero Crossing Rate of velocities

2. High-level Features:

- Note Sequence
- Duration
- Tempo
- Time Signature (numerator and denominator)
- Key Signature
- Average Velocity
- Maximum Velocity
- Minimum Velocity
- Velocity Standard Deviation
- Pitch Range
- Number of Instruments
- Note Density
- Number of Notes
- Average Pitch
- Maximum Pitch
- Minimum Pitch
- Pitch Standard Deviation
- Number of Articulations

Data Preprocessing Steps

1. **Load Extracted Features**: Load the CSV file containing the extracted features.
2. **Format Note Sequences**: Ensure the note sequences are correctly formatted as lists.
3. **Standardize Features**: Standardize numerical features using `StandardScaler` from `sklearn` to ensure they have a mean of 0 and a standard deviation of 1.
4. **Encode Target Labels**: Encode the target labels (composers) using `LabelEncoder` and convert them to categorical format using `to_categorical`.
5. **Pad Note Sequences**: Pad the note sequences to a uniform length (`max_len`) using `pad_sequences`.
6. **Prepare Input Features**: For each feature, expand its dimensions and repeat it to match the sequence length. Stack all features together along with the note sequences.
7. **Split Data**: Split the dataset into training and validation sets using `train_test_split`.

This ensures that the data is prepared appropriately for input into machine learning models, facilitating effective training and evaluation.

```
(1308, 100, 16)
(327, 100, 16)
(1308, 4)
(327, 4)
```

Data Split Summary The data split resulted in the following shapes:

- Training Features (X_train): (1308, 100, 16)
- Validation Features (X_val): (327, 100, 16)
- Training Labels (y_train): (1308, 4)
- Validation Labels (y_val): (327, 4)

1.3 LSTM Model for Composer Classification

1.3.1 Overview

This section outlines the implementation of an LSTM (Long Short-Term Memory) model for classifying music composers based on features extracted from MIDI files. The model leverages various hyperparameters, and a grid search is conducted to identify the optimal configuration for the best performance.

1.3.2 LSTM Model Architecture

The LSTM model is designed with the following layers:

1. **Input Layer**: Accepts sequences of shape `(max_len, 1)`.
2. **Bidirectional LSTM Layer**: Processes the input sequences in both forward and backward directions with `lstm_units` units.
3. **Dropout Layer**: Prevents overfitting by randomly dropping `dropout_rate` proportion of units.
4. **Batch Normalization Layer**: Normalizes the activations of the previous layer.
5. **Attention Mechanism**: Implements an attention mechanism to focus on important parts of the sequence.
6. **Second Bidirectional LSTM Layer**: Further processes the sequences with `lstm_units` units.
7. **Second Dropout Layer**: Prevents overfitting by randomly dropping `dropout_rate` proportion of units.
8. **Second Batch Normalization Layer**: Normalizes the activations of the previous layer.
9. **Dense Layer**: Fully connected layer with 128 units and ReLU activation.
10. **Third Dropout Layer**: Prevents overfitting by randomly dropping `dropout_rate` proportion of units.
11. **Output Layer**: Fully connected layer with softmax activation for classification.

1.3.3 Hyperparameter Tuning

A grid search is conducted over the following hyperparameters to find the best configuration: - **Optimizer**: ['adam', 'rmsprop', 'nadam'] - **Learning Rate**: [0.001, 0.01, 0.1] - **LSTM Units**: [64, 128, 256] - **Dropout Rate**: [0.1, 0.2, 0.3] - **Batch Size**: [8, 32, 64] - **Epochs**: [10, 20, 50, 100]

1.3.4 Training Process

1. **Model Building**: The model is built using the specified hyperparameters.
2. **Callbacks**: Various callbacks are used, including early stopping, learning rate reduction on plateau, and learning rate scheduler.
3. **Progress Monitoring**: The `TqdmCallback` provides a progress bar to monitor the training process.
4. **Evaluation**: Each model configuration is evaluated on the validation set, and the best configuration is selected based on validation accuracy.

```
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=16,
epochs=20, learning_rate=0.001

100%|      | 20/20 [01:38<00:00,  4.95s/it, accuracy=0.7131,
loss=0.7063, val_accuracy=0.6976, val_loss=0.7500]

Validation Accuracy: 69.15%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=16,
epochs=50, learning_rate=0.001

100%|      | 50/50 [03:51<00:00,  4.62s/it, accuracy=0.7915,
loss=0.5354, val_accuracy=0.7854, val_loss=0.6257]

Validation Accuracy: 78.66%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=16,
epochs=100, learning_rate=0.001

 62%|       | 62/100 [04:44<02:54,  4.59s/it, accuracy=0.8129,
loss=0.4713, val_accuracy=0.7927, val_loss=0.5432]

Validation Accuracy: 79.39%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=32,
epochs=20, learning_rate=0.001

100%|      | 20/20 [00:50<00:00,  2.55s/it, accuracy=0.6505,
loss=0.8347, val_accuracy=0.6183, val_loss=0.9218]

Validation Accuracy: 64.51%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=32,
epochs=50, learning_rate=0.001

100%|      | 50/50 [02:00<00:00,  2.41s/it, accuracy=0.7680,
loss=0.6069, val_accuracy=0.7451, val_loss=0.6965]

Validation Accuracy: 74.39%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=32,
epochs=100, learning_rate=0.001

 75%|       | 75/100 [02:59<00:59,  2.39s/it, accuracy=0.7982,
loss=0.5304, val_accuracy=0.7524, val_loss=0.6331]

Validation Accuracy: 75.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=64,
epochs=20, learning_rate=0.001
```

```
100%|     | 20/20 [00:28<00:00,  1.45s/it, accuracy=0.5440,
loss=1.0543, val_accuracy=0.5159, val_loss=1.0710]

Validation Accuracy: 51.59%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:05<00:00,  1.30s/it, accuracy=0.5281,
loss=1.0889, val_accuracy=0.5329, val_loss=1.0868]

Validation Accuracy: 53.05%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=64,
epochs=100, learning_rate=0.001

 73%|      | 73/100 [01:32<00:34,  1.27s/it, accuracy=0.5287,
loss=1.0816, val_accuracy=0.5244, val_loss=1.0900]

Validation Accuracy: 52.44%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=16,
epochs=20, learning_rate=0.001

100%|     | 20/20 [01:36<00:00,  4.83s/it, accuracy=0.6374,
loss=0.8732, val_accuracy=0.6256, val_loss=0.9017]

Validation Accuracy: 61.46%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=16,
epochs=50, learning_rate=0.001

100%|     | 50/50 [03:50<00:00,  4.61s/it, accuracy=0.7207,
loss=0.6713, val_accuracy=0.7402, val_loss=0.6967]

Validation Accuracy: 74.02%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=16,
epochs=100, learning_rate=0.001

 76%|      | 76/100 [05:49<01:50,  4.60s/it, accuracy=0.7253,
loss=0.7012, val_accuracy=0.7220, val_loss=0.6998]

Validation Accuracy: 72.56%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=32,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:50<00:00,  2.55s/it, accuracy=0.6157,
loss=0.9152, val_accuracy=0.5854, val_loss=0.9612]

Validation Accuracy: 58.54%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=32,
epochs=50, learning_rate=0.001

100%|     | 50/50 [02:01<00:00,  2.44s/it, accuracy=0.7131,
loss=0.7095, val_accuracy=0.7061, val_loss=0.7465]

Validation Accuracy: 70.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=32,
epochs=100, learning_rate=0.001
```

```
 69%|      | 69/100 [02:44<01:13,  2.38s/it, accuracy=0.6920,
loss=0.7586, val_accuracy=0.6780, val_loss=0.8080]

Validation Accuracy: 67.44%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=64,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:28<00:00,  1.44s/it, accuracy=0.5632,
loss=1.0354, val_accuracy=0.5561, val_loss=1.0249]

Validation Accuracy: 55.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:04<00:00,  1.29s/it, accuracy=0.5147,
loss=1.1309, val_accuracy=0.4988, val_loss=1.1207]

Validation Accuracy: 49.88%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=64,
epochs=100, learning_rate=0.001

 89%|     | 89/100 [01:52<00:13,  1.27s/it, accuracy=0.6426,
loss=0.8788, val_accuracy=0.6195, val_loss=0.9217]

Validation Accuracy: 62.20%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=16,
epochs=20, learning_rate=0.001

100%|     | 20/20 [01:37<00:00,  4.86s/it, accuracy=0.5690,
loss=1.0133, val_accuracy=0.5500, val_loss=1.0546]

Validation Accuracy: 54.63%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=16,
epochs=50, learning_rate=0.001

100%|     | 50/50 [03:50<00:00,  4.61s/it, accuracy=0.6050,
loss=0.9356, val_accuracy=0.6134, val_loss=0.9152]

Validation Accuracy: 61.34%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=16,
epochs=100, learning_rate=0.001

 68%|      | 68/100 [05:13<02:27,  4.61s/it, accuracy=0.6438,
loss=0.8529, val_accuracy=0.6280, val_loss=0.8678]

Validation Accuracy: 62.56%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=32,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:51<00:00,  2.56s/it, accuracy=0.5308,
loss=1.0945, val_accuracy=0.4878, val_loss=1.1642]

Validation Accuracy: 53.90%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=32,
epochs=50, learning_rate=0.001
```

```
100%|     | 50/50 [02:02<00:00,  2.44s/it, accuracy=0.6078,
loss=0.9388, val_accuracy=0.5939, val_loss=0.9515]

Validation Accuracy: 59.76%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=32,
epochs=100, learning_rate=0.001

 70%|       | 70/100 [02:47<01:11,  2.39s/it, accuracy=0.5955,
loss=0.9356, val_accuracy=0.5927, val_loss=0.9344]

Validation Accuracy: 59.63%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=64,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:30<00:00,  1.52s/it, accuracy=0.4780,
loss=1.2158, val_accuracy=0.4768, val_loss=1.1963]

Validation Accuracy: 47.68%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:06<00:00,  1.32s/it, accuracy=0.5611,
loss=1.0046, val_accuracy=0.5549, val_loss=1.0181]

Validation Accuracy: 55.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=64,
epochs=100, learning_rate=0.001

 68%|       | 68/100 [01:26<00:40,  1.27s/it, accuracy=0.4249,
loss=1.2468, val_accuracy=0.4354, val_loss=1.2481]

Validation Accuracy: 43.54%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=16,
epochs=20, learning_rate=0.001

100%|     | 20/20 [01:37<00:00,  4.86s/it, accuracy=0.7491,
loss=0.6131, val_accuracy=0.7390, val_loss=0.7095]

Validation Accuracy: 72.93%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=16,
epochs=50, learning_rate=0.001

100%|     | 50/50 [03:52<00:00,  4.64s/it, accuracy=0.8977,
loss=0.2843, val_accuracy=0.8622, val_loss=0.4576]

Validation Accuracy: 85.98%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=16,
epochs=100, learning_rate=0.001

 49%|        | 49/100 [03:51<04:01,  4.73s/it, accuracy=0.8739,
loss=0.3497, val_accuracy=0.8220, val_loss=0.5594]

Validation Accuracy: 82.20%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=32,
epochs=20, learning_rate=0.001
```

```
100%|     | 20/20 [00:51<00:00,  2.56s/it, accuracy=0.7411,
loss=0.6751, val_accuracy=0.6829, val_loss=0.8171]

Validation Accuracy: 69.76%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=32,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:55<00:00,  2.31s/it, accuracy=0.8117,
loss=0.4821, val_accuracy=0.8049, val_loss=0.5868]

Validation Accuracy: 80.12%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=32,
epochs=100, learning_rate=0.001

 80%|      | 80/100 [03:05<00:46,  2.32s/it, accuracy=0.8706,
loss=0.3602, val_accuracy=0.8244, val_loss=0.5043]

Validation Accuracy: 82.44%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=64,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:27<00:00,  1.38s/it, accuracy=0.5409,
loss=1.0572, val_accuracy=0.5341, val_loss=1.0742]

Validation Accuracy: 53.54%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:03<00:00,  1.26s/it, accuracy=0.5632,
loss=1.0279, val_accuracy=0.5329, val_loss=1.0498]

Validation Accuracy: 53.41%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=64,
epochs=100, learning_rate=0.001

 51%|        | 51/100 [01:04<01:02,  1.27s/it, accuracy=0.5720,
loss=1.0098, val_accuracy=0.5488, val_loss=1.0389]

Validation Accuracy: 54.88%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=16,
epochs=20, learning_rate=0.001

100%|     | 20/20 [01:39<00:00,  4.96s/it, accuracy=0.6746,
loss=0.7894, val_accuracy=0.6927, val_loss=0.7809]

Validation Accuracy: 69.27%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=16,
epochs=50, learning_rate=0.001

100%|     | 50/50 [03:57<00:00,  4.74s/it, accuracy=0.8028,
loss=0.4878, val_accuracy=0.7768, val_loss=0.5699]

Validation Accuracy: 77.68%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=16,
epochs=100, learning_rate=0.001
```

```
 83%|      | 83/100 [06:28<01:19,  4.68s/it, accuracy=0.7848,
loss=0.5694, val_accuracy=0.7659, val_loss=0.6635]

Validation Accuracy: 76.95%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=32,
epochs=20, learning_rate=0.001

100%|      | 20/20 [00:49<00:00,  2.48s/it, accuracy=0.6129,
loss=0.9222, val_accuracy=0.5695, val_loss=0.9881]

Validation Accuracy: 61.34%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=32,
epochs=50, learning_rate=0.001

100%|      | 50/50 [01:57<00:00,  2.36s/it, accuracy=0.7677,
loss=0.5974, val_accuracy=0.7427, val_loss=0.6881]

Validation Accuracy: 74.76%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=32,
epochs=100, learning_rate=0.001

 56%|       | 56/100 [02:13<01:44,  2.38s/it, accuracy=0.7561,
loss=0.6173, val_accuracy=0.7488, val_loss=0.7010]

Validation Accuracy: 74.76%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=64,
epochs=20, learning_rate=0.001

100%|      | 20/20 [00:28<00:00,  1.41s/it, accuracy=0.6081,
loss=0.9505, val_accuracy=0.5744, val_loss=0.9724]

Validation Accuracy: 57.44%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=64,
epochs=50, learning_rate=0.001

100%|      | 50/50 [01:02<00:00,  1.26s/it, accuracy=0.5198,
loss=1.1221, val_accuracy=0.5268, val_loss=1.1137]

Validation Accuracy: 52.68%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=64,
epochs=100, learning_rate=0.001

 71%|       | 71/100 [01:27<00:35,  1.24s/it, accuracy=0.5272,
loss=1.1031, val_accuracy=0.5207, val_loss=1.1005]

Validation Accuracy: 52.07%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=16,
epochs=20, learning_rate=0.001

100%|      | 20/20 [01:37<00:00,  4.90s/it, accuracy=0.6285,
loss=0.9050, val_accuracy=0.6671, val_loss=0.8277]

Validation Accuracy: 66.71%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=16,
epochs=50, learning_rate=0.001
```

```
100%|     | 50/50 [03:55<00:00,  4.71s/it, accuracy=0.7405,
loss=0.6590, val_accuracy=0.7280, val_loss=0.7122]

Validation Accuracy: 72.80%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=16,
epochs=100, learning_rate=0.001

 73%|      | 73/100 [05:45<02:07,  4.73s/it, accuracy=0.6758,
loss=0.7745, val_accuracy=0.6732, val_loss=0.8317]

Validation Accuracy: 67.56%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=32,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:50<00:00,  2.51s/it, accuracy=0.5647,
loss=1.0146, val_accuracy=0.5720, val_loss=0.9960]

Validation Accuracy: 57.20%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=32,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:56<00:00,  2.33s/it, accuracy=0.7128,
loss=0.7035, val_accuracy=0.6951, val_loss=0.7619]

Validation Accuracy: 70.24%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=32,
epochs=100, learning_rate=0.001

 90%|     | 90/100 [03:22<00:22,  2.25s/it, accuracy=0.6960,
loss=0.7427, val_accuracy=0.6902, val_loss=0.7788]

Validation Accuracy: 69.27%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=64,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:30<00:00,  1.50s/it, accuracy=0.5580,
loss=1.0423, val_accuracy=0.5427, val_loss=1.0583]

Validation Accuracy: 54.27%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:03<00:00,  1.27s/it, accuracy=0.6368,
loss=0.8852, val_accuracy=0.6085, val_loss=0.9366]

Validation Accuracy: 60.49%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=64,
epochs=100, learning_rate=0.001

 96%|     | 96/100 [01:54<00:04,  1.19s/it, accuracy=0.6380,
loss=0.8820, val_accuracy=0.6293, val_loss=0.9009]

Validation Accuracy: 62.68%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=16,
epochs=20, learning_rate=0.001
```

```
100%|     | 20/20 [01:30<00:00,  4.55s/it, accuracy=0.4863,
loss=1.1809, val_accuracy=0.4244, val_loss=1.2893]

Validation Accuracy: 49.02%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=16,
epochs=50, learning_rate=0.001

 92%|     | 46/50 [03:24<00:17,  4.45s/it, accuracy=0.9301,
loss=0.2083, val_accuracy=0.8695, val_loss=0.4640]

Validation Accuracy: 85.98%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=16,
epochs=100, learning_rate=0.001

 59%|       | 59/100 [04:18<02:59,  4.38s/it, accuracy=0.5098,
loss=1.1214, val_accuracy=0.5207, val_loss=1.1051]

Validation Accuracy: 52.07%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=32,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:50<00:00,  2.53s/it, accuracy=0.7598,
loss=0.6233, val_accuracy=0.7183, val_loss=0.7458]

Validation Accuracy: 73.29%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=32,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:57<00:00,  2.34s/it, accuracy=0.8987,
loss=0.2863, val_accuracy=0.8476, val_loss=0.4624]

Validation Accuracy: 83.66%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=32,
epochs=100, learning_rate=0.001

 47%|       | 47/100 [01:48<02:02,  2.31s/it, accuracy=0.9341,
loss=0.1936, val_accuracy=0.8732, val_loss=0.4479]

Validation Accuracy: 87.07%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=64,
epochs=20, learning_rate=0.001

100%|     | 20/20 [00:30<00:00,  1.51s/it, accuracy=0.7161,
loss=0.7211, val_accuracy=0.6817, val_loss=0.8265]

Validation Accuracy: 68.17%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:08<00:00,  1.37s/it, accuracy=0.8587,
loss=0.3934, val_accuracy=0.8256, val_loss=0.5569]

Validation Accuracy: 82.56%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.1, batch_size=64,
epochs=100, learning_rate=0.001
```

```
 58%|       | 58/100 [01:18<00:56,  1.36s/it, accuracy=0.6215,
loss=0.9409, val_accuracy=0.5951, val_loss=0.9913]

Validation Accuracy: 59.51%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=16,
epochs=20, learning_rate=0.001

100%|      | 20/20 [01:31<00:00,  4.55s/it, accuracy=0.6236,
loss=0.8935, val_accuracy=0.6280, val_loss=0.9417]

Validation Accuracy: 62.80%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=16,
epochs=50, learning_rate=0.001

100%|      | 50/50 [03:49<00:00,  4.60s/it, accuracy=0.8605,
loss=0.3627, val_accuracy=0.8451, val_loss=0.4865]

Validation Accuracy: 84.51%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=16,
epochs=100, learning_rate=0.001

 79%|       | 79/100 [05:57<01:35,  4.52s/it, accuracy=0.5171,
loss=1.1260, val_accuracy=0.5037, val_loss=1.1348]

Validation Accuracy: 50.24%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=32,
epochs=20, learning_rate=0.001

100%|      | 20/20 [00:49<00:00,  2.48s/it, accuracy=0.6517,
loss=0.8482, val_accuracy=0.6463, val_loss=0.8662]

Validation Accuracy: 64.63%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=32,
epochs=50, learning_rate=0.001

100%|      | 50/50 [01:59<00:00,  2.39s/it, accuracy=0.7711,
loss=0.6036, val_accuracy=0.7549, val_loss=0.6341]

Validation Accuracy: 75.49%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=32,
epochs=100, learning_rate=0.001

 65%|       | 65/100 [02:34<01:23,  2.38s/it, accuracy=0.8739,
loss=0.3460, val_accuracy=0.8415, val_loss=0.4984]

Validation Accuracy: 83.90%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=64,
epochs=20, learning_rate=0.001

100%|      | 20/20 [00:30<00:00,  1.54s/it, accuracy=0.5571,
loss=1.0518, val_accuracy=0.5354, val_loss=1.0686]

Validation Accuracy: 54.39%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=64,
epochs=50, learning_rate=0.001
```

```
100%|      | 50/50 [01:08<00:00,  1.37s/it, accuracy=0.5482,
loss=1.0583, val_accuracy=0.5341, val_loss=1.0725]

Validation Accuracy: 53.41%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.2, batch_size=64,
epochs=100, learning_rate=0.001

 88%|      | 88/100 [01:58<00:16,  1.34s/it, accuracy=0.5556,
loss=1.0370, val_accuracy=0.5427, val_loss=1.0559]

Validation Accuracy: 54.51%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=16,
epochs=20, learning_rate=0.001

100%|      | 20/20 [01:34<00:00,  4.72s/it, accuracy=0.5498,
loss=1.0521, val_accuracy=0.5073, val_loss=1.1126]

Validation Accuracy: 51.59%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=16,
epochs=50, learning_rate=0.001

100%|      | 50/50 [03:44<00:00,  4.49s/it, accuracy=0.7268,
loss=0.6708, val_accuracy=0.7207, val_loss=0.7164]

Validation Accuracy: 72.07%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=16,
epochs=100, learning_rate=0.001

 62%|       | 62/100 [04:37<02:50,  4.47s/it, accuracy=0.8104,
loss=0.4686, val_accuracy=0.7976, val_loss=0.5357]

Validation Accuracy: 80.12%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=32,
epochs=20, learning_rate=0.001

100%|      | 20/20 [00:49<00:00,  2.48s/it, accuracy=0.6126,
loss=0.9193, val_accuracy=0.6000, val_loss=0.9646]

Validation Accuracy: 60.00%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=32,
epochs=50, learning_rate=0.001

100%|      | 50/50 [01:56<00:00,  2.33s/it, accuracy=0.7112,
loss=0.7225, val_accuracy=0.7134, val_loss=0.7655]

Validation Accuracy: 70.61%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=32,
epochs=100, learning_rate=0.001

 90%|      | 90/100 [03:25<00:22,  2.29s/it, accuracy=0.8199,
loss=0.4888, val_accuracy=0.8256, val_loss=0.5416]

Validation Accuracy: 82.80%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=64,
epochs=20, learning_rate=0.001
```

```
100%|     | 20/20 [00:30<00:00,  1.53s/it, accuracy=0.4997,
loss=1.1423, val_accuracy=0.5159, val_loss=1.1365]

Validation Accuracy: 51.59%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=64,
epochs=50, learning_rate=0.001

100%|     | 50/50 [01:13<00:00,  1.47s/it, accuracy=0.6981,
loss=0.7516, val_accuracy=0.6890, val_loss=0.7945]

Validation Accuracy: 68.90%
Training with optimizer=adam, lstm_units=256, dropout_rate=0.3, batch_size=64,
epochs=100, learning_rate=0.001

 78%|      | 78/100 [01:45<00:29,  1.35s/it, accuracy=0.7784,
loss=0.5757, val_accuracy=0.7500, val_loss=0.6961]

Validation Accuracy: 75.24%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=16,
epochs=20, learning_rate=0.01

 80%|      | 16/20 [01:21<00:20,  5.11s/it, accuracy=0.2573,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3875]

Validation Accuracy: 26.95%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=16,
epochs=50, learning_rate=0.01

 26%|         | 13/50 [01:06<03:09,  5.13s/it, accuracy=0.2564,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3872]

Validation Accuracy: 26.95%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=16,
epochs=100, learning_rate=0.01

 11%|          | 11/100 [00:57<07:42,  5.20s/it, accuracy=0.2558,
loss=1.3864, val_accuracy=0.2244, val_loss=1.3876]

Validation Accuracy: 26.95%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=32,
epochs=20, learning_rate=0.01

100%|     | 20/20 [00:53<00:00,  2.66s/it, accuracy=0.4142,
loss=1.2558, val_accuracy=0.4073, val_loss=1.2637]

Validation Accuracy: 40.73%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=32,
epochs=50, learning_rate=0.01

 90%|      | 45/50 [01:53<00:12,  2.52s/it, accuracy=0.9008,
loss=0.2648, val_accuracy=0.8488, val_loss=0.5305]

Validation Accuracy: 84.02%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=32,
epochs=100, learning_rate=0.01
```

```
 59%|       | 59/100 [02:29<01:43,  2.53s/it, accuracy=0.5214,
loss=1.0693, val_accuracy=0.5390, val_loss=1.0242]

Validation Accuracy: 53.78%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=64,
epochs=20, learning_rate=0.01

100%|      | 20/20 [00:29<00:00,  1.49s/it, accuracy=0.8468,
loss=0.4110, val_accuracy=0.7793, val_loss=0.5873]

Validation Accuracy: 77.93%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=64,
epochs=50, learning_rate=0.01

100%|      | 50/50 [01:06<00:00,  1.34s/it, accuracy=0.9142,
loss=0.2342, val_accuracy=0.8415, val_loss=0.4785]

Validation Accuracy: 84.63%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.1, batch_size=64,
epochs=100, learning_rate=0.01

 88%|      | 88/100 [01:54<00:15,  1.30s/it, accuracy=0.6603,
loss=0.8403, val_accuracy=0.6354, val_loss=0.8605]

Validation Accuracy: 63.29%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=16,
epochs=20, learning_rate=0.01

 80%|      | 16/20 [01:20<00:20,  5.04s/it, accuracy=0.2564,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3877]

Validation Accuracy: 25.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=16,
epochs=50, learning_rate=0.01

100%|      | 50/50 [03:56<00:00,  4.72s/it, accuracy=0.3297,
loss=1.3306, val_accuracy=0.3061, val_loss=1.3200]

Validation Accuracy: 30.12%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=16,
epochs=100, learning_rate=0.01

 12%|         | 12/100 [01:01<07:28,  5.10s/it, accuracy=0.2543,
loss=1.3854, val_accuracy=0.2244, val_loss=1.3839]

Validation Accuracy: 24.51%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=32,
epochs=20, learning_rate=0.01

100%|      | 20/20 [00:52<00:00,  2.61s/it, accuracy=0.4963,
loss=1.1491, val_accuracy=0.4866, val_loss=1.1391]

Validation Accuracy: 47.80%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=32,
epochs=50, learning_rate=0.01
```

```
 74%|      | 37/50 [01:32<00:32,  2.49s/it, accuracy=0.4008,
loss=1.2809, val_accuracy=0.4061, val_loss=1.2871]

Validation Accuracy: 39.88%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=32,
epochs=100, learning_rate=0.01

 56%|       | 56/100 [02:16<01:46,  2.43s/it, accuracy=0.4164,
loss=1.2576, val_accuracy=0.4159, val_loss=1.2583]

Validation Accuracy: 41.59%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=64,
epochs=20, learning_rate=0.01

100%|     | 20/20 [00:29<00:00,  1.46s/it, accuracy=0.5601,
loss=1.0022, val_accuracy=0.5707, val_loss=0.9961]

Validation Accuracy: 57.07%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=64,
epochs=50, learning_rate=0.01

100%|     | 50/50 [01:11<00:00,  1.44s/it, accuracy=0.5314,
loss=1.0537, val_accuracy=0.5049, val_loss=1.0741]

Validation Accuracy: 50.49%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.2, batch_size=64,
epochs=100, learning_rate=0.01

 75%|      | 75/100 [01:38<00:32,  1.32s/it, accuracy=0.6371,
loss=0.8716, val_accuracy=0.6402, val_loss=0.8937]

Validation Accuracy: 63.78%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=16,
epochs=20, learning_rate=0.01

 55%|       | 11/20 [00:57<00:46,  5.19s/it, accuracy=0.2561,
loss=1.3862, val_accuracy=0.2244, val_loss=1.3872]

Validation Accuracy: 25.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=16,
epochs=50, learning_rate=0.01

 72%|      | 36/50 [02:53<01:07,  4.83s/it, accuracy=0.3877,
loss=1.2889, val_accuracy=0.3854, val_loss=1.2886]

Validation Accuracy: 38.05%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=16,
epochs=100, learning_rate=0.01

 17%|         | 17/100 [01:23<06:49,  4.93s/it, accuracy=0.2579,
loss=1.3862, val_accuracy=0.2244, val_loss=1.3879]

Validation Accuracy: 25.61%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=32,
epochs=20, learning_rate=0.01
```

```
100%|     | 20/20 [00:52<00:00,  2.64s/it, accuracy=0.3910,
loss=1.2932, val_accuracy=0.3841, val_loss=1.2903]

Validation Accuracy: 38.41%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=32,
epochs=50, learning_rate=0.01

 94%|     | 47/50 [01:57<00:07,  2.50s/it, accuracy=0.3895,
loss=1.2934, val_accuracy=0.3927, val_loss=1.2920]

Validation Accuracy: 39.51%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=32,
epochs=100, learning_rate=0.01

 67%|      | 67/100 [02:42<01:20,  2.43s/it, accuracy=0.5232,
loss=1.0876, val_accuracy=0.5512, val_loss=1.0556]

Validation Accuracy: 55.49%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=64,
epochs=20, learning_rate=0.01

100%|     | 20/20 [00:29<00:00,  1.46s/it, accuracy=0.4124,
loss=1.2745, val_accuracy=0.4122, val_loss=1.2730]

Validation Accuracy: 40.12%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=64,
epochs=50, learning_rate=0.01

100%|     | 50/50 [01:06<00:00,  1.32s/it, accuracy=0.4576,
loss=1.2172, val_accuracy=0.4720, val_loss=1.2236]

Validation Accuracy: 47.07%
Training with optimizer=adam, lstm_units=64, dropout_rate=0.3, batch_size=64,
epochs=100, learning_rate=0.01

 50%|       | 50/100 [01:06<01:06,  1.33s/it, accuracy=0.7854,
loss=0.5546, val_accuracy=0.7585, val_loss=0.6412]

Validation Accuracy: 76.22%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=16,
epochs=20, learning_rate=0.01

 70%|      | 14/20 [01:09<00:29,  4.97s/it, accuracy=0.2564,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3874]

Validation Accuracy: 26.95%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=16,
epochs=50, learning_rate=0.01

 32%|       | 16/50 [01:19<02:48,  4.95s/it, accuracy=0.2561,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3876]

Validation Accuracy: 25.00%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=16,
epochs=100, learning_rate=0.01
```

```
 11%|          | 11/100 [00:56<07:34,  5.11s/it, accuracy=0.2564,
loss=1.3864, val_accuracy=0.2244, val_loss=1.3875]

Validation Accuracy: 26.95%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=32,
epochs=20, learning_rate=0.01

100%|     | 20/20 [00:49<00:00,  2.46s/it, accuracy=0.3913,
loss=1.2775, val_accuracy=0.4049, val_loss=1.2823]

Validation Accuracy: 39.88%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=32,
epochs=50, learning_rate=0.01

 92%|     | 46/50 [01:46<00:09,  2.31s/it, accuracy=0.4243,
loss=1.2508, val_accuracy=0.4134, val_loss=1.2545]

Validation Accuracy: 41.71%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=32,
epochs=100, learning_rate=0.01

 89%|     | 89/100 [03:21<00:24,  2.27s/it, accuracy=0.4991,
loss=1.0968, val_accuracy=0.5049, val_loss=1.0741]

Validation Accuracy: 50.24%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=64,
epochs=20, learning_rate=0.01

100%|     | 20/20 [00:27<00:00,  1.40s/it, accuracy=0.4936,
loss=1.1278, val_accuracy=0.4780, val_loss=1.1437]

Validation Accuracy: 47.80%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=64,
epochs=50, learning_rate=0.01

100%|     | 50/50 [01:02<00:00,  1.25s/it, accuracy=0.5006,
loss=1.1517, val_accuracy=0.4756, val_loss=1.1633]

Validation Accuracy: 47.56%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.1, batch_size=64,
epochs=100, learning_rate=0.01

 71%|      | 71/100 [01:26<00:35,  1.22s/it, accuracy=0.4405,
loss=1.2319, val_accuracy=0.4402, val_loss=1.2338]

Validation Accuracy: 44.15%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=16,
epochs=20, learning_rate=0.01

 55%|      | 11/20 [00:55<00:45,  5.05s/it, accuracy=0.2546,
loss=1.3869, val_accuracy=0.2244, val_loss=1.3875]

Validation Accuracy: 28.66%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=16,
epochs=50, learning_rate=0.01
```

```
 28%|        | 14/50 [01:09<02:57,  4.94s/it, accuracy=0.2567,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3877]

Validation Accuracy: 22.44%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=16,
epochs=100, learning_rate=0.01

 20%|         | 20/100 [01:45<07:00,  5.25s/it, accuracy=0.2564,
loss=1.3862, val_accuracy=0.2244, val_loss=1.3877]

Validation Accuracy: 26.95%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=32,
epochs=20, learning_rate=0.01

 65%|      | 13/20 [00:34<00:18,  2.65s/it, accuracy=0.2564,
loss=1.3867, val_accuracy=0.2244, val_loss=1.3874]

Validation Accuracy: 25.00%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=32,
epochs=50, learning_rate=0.01

100%|     | 50/50 [01:58<00:00,  2.38s/it, accuracy=0.3977,
loss=1.2862, val_accuracy=0.4024, val_loss=1.2830]

Validation Accuracy: 41.10%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=32,
epochs=100, learning_rate=0.01

 11%|         | 11/100 [00:29<04:00,  2.70s/it, accuracy=0.2561,
loss=1.3863, val_accuracy=0.2244, val_loss=1.3877]

Validation Accuracy: 25.61%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=64,
epochs=20, learning_rate=0.01

100%|     | 20/20 [00:28<00:00,  1.41s/it, accuracy=0.3880,
loss=1.2797, val_accuracy=0.3817, val_loss=1.3097]

Validation Accuracy: 41.46%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=64,
epochs=50, learning_rate=0.01

 90%|     | 45/50 [00:57<00:06,  1.27s/it, accuracy=0.3874,
loss=1.2855, val_accuracy=0.3927, val_loss=1.2768]

Validation Accuracy: 39.15%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.2, batch_size=64,
epochs=100, learning_rate=0.01

 89%|     | 89/100 [01:48<00:13,  1.21s/it, accuracy=0.4515,
loss=1.2135, val_accuracy=0.4573, val_loss=1.2348]

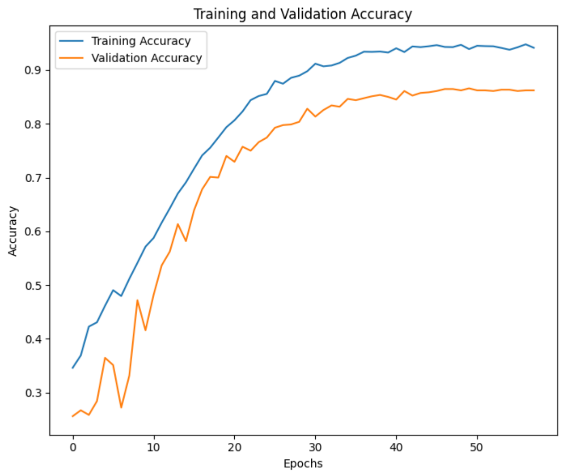
Validation Accuracy: 45.73%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=16,
epochs=20, learning_rate=0.01
```

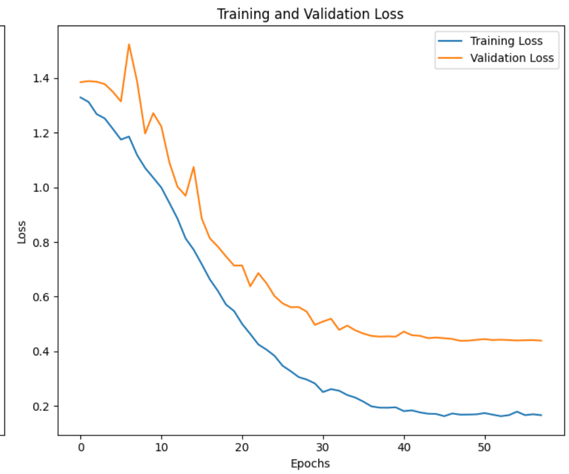
```
100%|      | 20/20 [01:37<00:00,  4.89s/it, accuracy=0.2564,
loss=1.3866, val_accuracy=0.2244, val_loss=1.3879]
```

```
Validation Accuracy: 25.00%
Training with optimizer=adam, lstm_units=128, dropout_rate=0.3, batch_size=16,
epochs=50, learning_rate=0.01
```

```
 12%|          | 6/50 [00:32<03:36,  4.91s/it, accuracy=0.2381,
loss=1.3883, val_accuracy=0.2244, val_loss=1.3887]
```

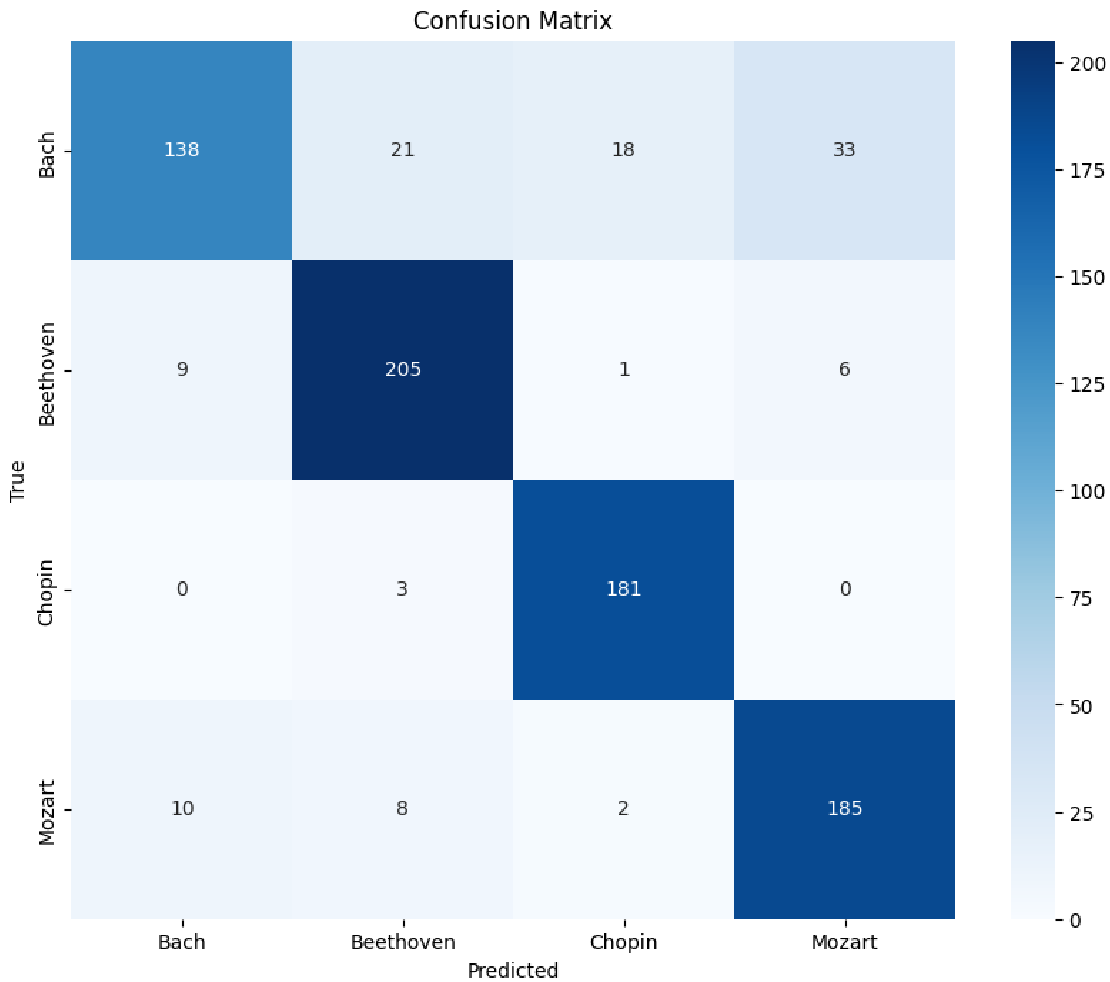
1.4 Visualizing training and validation accuracy & loss





1.4.1 Performance classification report

```
26/26              0s 17ms/step -
accuracy: 0.8573 - loss: 0.5052
Validation Accuracy: 86.46%
26/26              1s 24ms/step
```



	precision	recall	f1-score	support
Bach	0.88	0.66	0.75	210
Beethoven	0.86	0.93	0.90	221
Chopin	0.90	0.98	0.94	184
Mozart	0.83	0.90	0.86	205
accuracy			0.86	820
macro avg	0.87	0.87	0.86	820
weighted avg	0.87	0.86	0.86	820

1.5 CNN Model Architecture Summary

The Convolutional Neural Network (CNN) model used in this project is tailored for sequence data analysis, particularly for classifying musical pieces based on extracted MIDI features. The model comprises several layers designed to capture and process temporal patterns effectively:

1. **Input Layer**: Accepts input sequences of length 196 with 32 features each.
2. **First Convolutional Block**:
   - **Conv1D Layer**: Applies 32 filters with a kernel size of 3 to detect local patterns in the sequences.
   - **Batch Normalization**: Normalizes the activations, stabilizing the learning process.
   - **MaxPooling1D Layer**: Reduces dimensionality by taking the maximum value over a pool size of 2.
   - **Dropout Layer**: Prevents overfitting by randomly setting a fraction of the input units to zero.
3. **Second Convolutional Block**:
   - **Conv1D Layer**: Applies 64 filters, enhancing the model's ability to capture more complex patterns.
   - **Batch Normalization**, **MaxPooling1D**, and **Dropout** layers follow similar to the first block.
4. **Third Convolutional Block**:
   - **Conv1D Layer**: Increases the filter count to 128, further capturing intricate features.
   - **Batch Normalization**, **MaxPooling1D**, and **Dropout** layers are included as before.
5. **Flatten Layer**: Converts the 3D output of the last convolutional block to a 1D vector, preparing it for the dense layers.
6. **Fully Connected Layers**:
   - **Dense Layer**: Contains 256 units with ReLU activation, learning high-level representations.
   - **Dropout Layer**: Applied to prevent overfitting.
   - **Output Dense Layer**: Utilizes a softmax activation function to output class probabilities for the four composers.

The model, with a total of `2,224,782` parameters, leverages the power of convolutional layers to capture temporal dependencies and patterns in the MIDI data, enabling effective classification of musical pieces.

```
Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
```

```
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
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dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
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dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

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Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
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dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

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Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

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Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

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Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
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dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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```
Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001
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Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
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Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
```

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dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
```

```
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
```

```
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100,
learning_rate=0.001

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01
```

```
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
```

```
Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01
```

```
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
```

```
Training with optimizer=adam, filters=32, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01
```

```
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=3, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]
```

```
Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=2,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]

Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.1, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01
```

```
Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=128, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=32, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Training with optimizer=adam, filters=64, kernel_size=5, pool_size=3,
dropout_rate=0.2, dense_units=256, batch_size=64, epochs=100, learning_rate=0.01

Training Progress:   0%|          | 0/100 [00:00<?, ?it/s]


Best Validation Accuracy: 95.24%

Best Parameters: ('adam', 0.001, 32, 5, 2, 0.1, 256, 32, 100)
```

1.5.1 Model Evaluation and Performance Analysis

Training and Validation Accuracy and Loss The plots below represent the training and validation accuracy and loss over the epochs for the best model configuration. The training process shows how well the model is learning and generalizing to new data.

Accuracy Plot

- **Training Accuracy**: The accuracy of the model on the training data.
- **Validation Accuracy**: The accuracy of the model on the validation data.

The accuracy graph (left) shows the accuracy of the model on the training and validation datasets over each epoch.

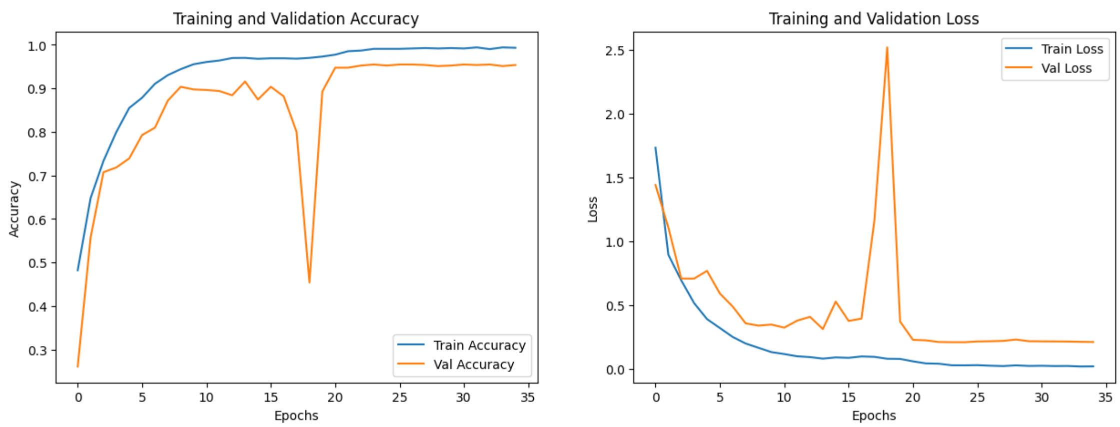
1. **Initial Phase**: In the initial epochs, both training and validation accuracy increase rapidly, indicating that the model is learning from the data.
2. **Mid-Phase**: Around epoch 10, the training accuracy continues to improve, while the validation accuracy starts to fluctuate. This fluctuation indicates that the model is beginning to overfit the training data.
3. **Stabilization**: After epoch 25, both training and validation accuracies stabilize, with the training accuracy slightly higher than the validation accuracy. The model has learned the training data well, but some overfitting might be present as the validation accuracy does not increase as much as the training accuracy.

Loss Plot

- **Training Loss**: The loss of the model on the training data.
- **Validation Loss**: The loss of the model on the validation data.

The loss graph (right) shows the loss of the model on the training and validation datasets over each epoch.

1. **Initial Phase**: In the initial epochs, both training and validation loss decrease rapidly, indicating that the model is reducing errors and improving its predictions.
2. **Mid-Phase**: Around epoch 10, the validation loss begins to fluctuate significantly while the training loss continues to decrease. This fluctuation is another sign of overfitting, as the model performs well on training data but not as consistently on validation data.
3. **Stabilization**: After epoch 25, the training loss remains low and stable, while the validation loss stabilizes at a higher value than the training loss. This difference between training and validation loss is another indicator of overfitting.



1.5.2 Confusion Matrix

The confusion matrix visualizes the performance of the classification model by showing the true positive, false positive, true negative, and false negative predictions for each class.

- **Diagonal Elements**: Correct predictions.
- **Off-Diagonal Elements**: Misclassifications.

1.5.3 Classification Report

The classification report provides detailed metrics for each class, including precision, recall, and F1-score. These metrics help to understand the performance of the model on each class in the dataset.

Precision

- The ratio of correctly predicted positive observations to the total predicted positives.

Recall

- The ratio of correctly predicted positive observations to all observations in the actual class.

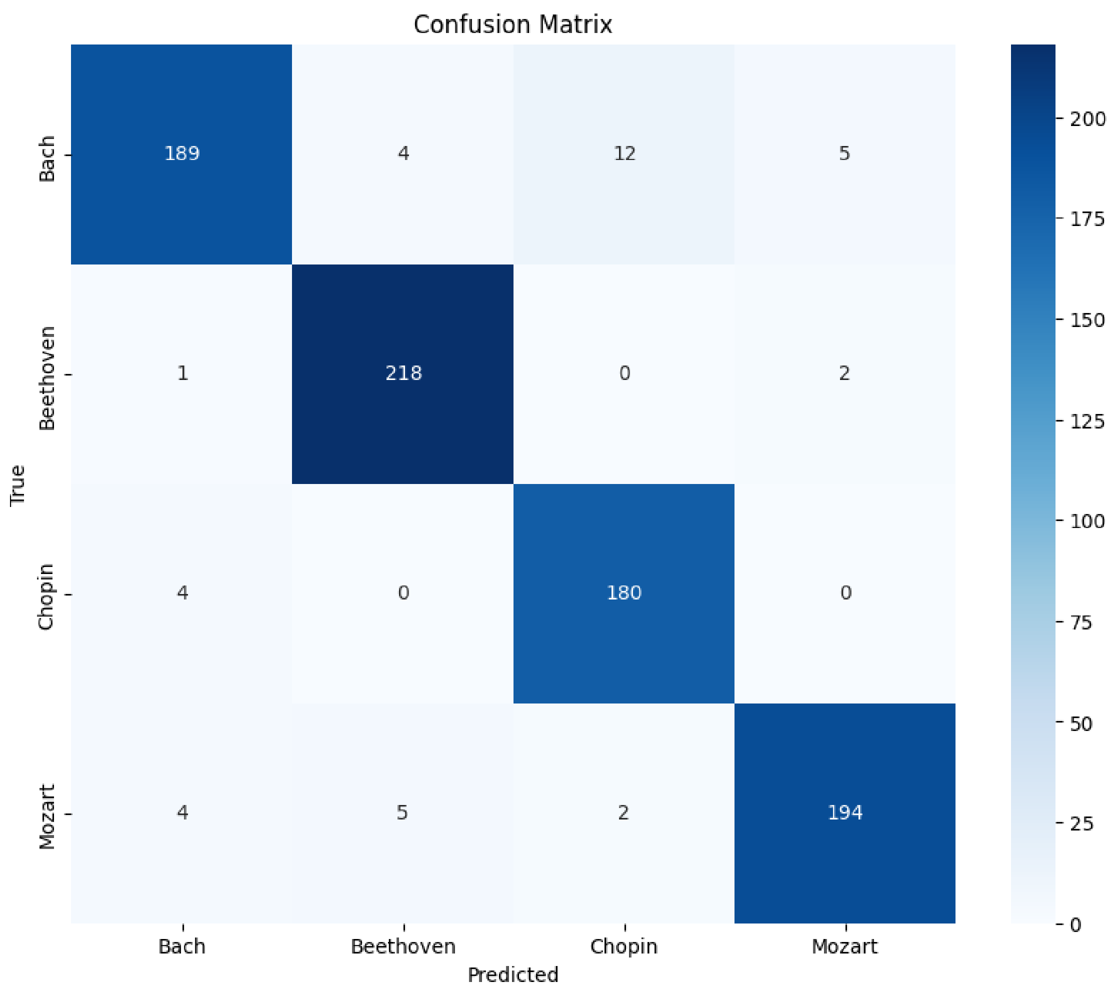
F1-score

- The weighted average of Precision and Recall.

1.5.4 Conclusion

The model shows a high level of accuracy and performance across all classes, with precision, recall, and F1-scores all around 95%. The confusion matrix confirms that most predictions are correct, with very few misclassifications. This indicates that the model is robust and performs well on the given task of composer classification based on MIDI file features.

```
26/26                  1s 26ms/step
```




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

```
        Bach       0.95      0.90      0.93       210
   Beethoven       0.96      0.99      0.97       221
      Chopin       0.93      0.98      0.95       184
      Mozart       0.97      0.95      0.96       205

    accuracy                           0.95       820
   macro avg       0.95      0.95      0.95       820
weighted avg       0.95      0.95      0.95       820
```

```
Model: "sequential_84"


 Layer (type)                    Output Shape                  ␣
↪Param #

 conv1d_252 (Conv1D)             (None, 196, 32)                   ␣
↪192

 batch_normalization_252         (None, 196, 32)                   ␣
↪128
 (BatchNormalization)                                              ␣
↪

 max_pooling1d_252 (MaxPooling1D)   (None, 98, 32)                 ␣
↪  0

 dropout_336 (Dropout)           (None, 98, 32)                    ␣
↪  0

 conv1d_253 (Conv1D)             (None, 94, 64)                 ␣
↪10,304

 batch_normalization_253         (None, 94, 64)                    ␣
↪256
 (BatchNormalization)                                              ␣
↪

 max_pooling1d_253 (MaxPooling1D)   (None, 47, 64)                 ␣
↪  0

 dropout_337 (Dropout)           (None, 47, 64)                    ␣
↪  0

 conv1d_254 (Conv1D)             (None, 43, 128)                ␣
↪41,088
```

```
 batch_normalization_254              (None, 43, 128)                      ␣
↪512
 (BatchNormalization)                                                      ␣
↪

 max_pooling1d_254 (MaxPooling1D)     (None, 21, 128)                      ␣
↪  0

 dropout_338 (Dropout)                (None, 21, 128)                      ␣
↪  0

 flatten_84 (Flatten)                 (None, 2688)                         ␣
↪  0

 dense_168 (Dense)                    (None, 256)                      ␣
↪688,384

 dropout_339 (Dropout)                (None, 256)                          ␣
↪  0

 dense_169 (Dense)                    (None, 4)                          ␣
↪1,028


 Total params: 2,224,782 (8.49 MB)

 Trainable params: 741,444 (2.83 MB)

 Non-trainable params: 448 (1.75 KB)

 Optimizer params: 1,482,890 (5.66 MB)
```

1.6 Transformer Self-Attention Model

The Transformer model, introduced by Vaswani et al. in 2017, has revolutionized the field of natural language processing (NLP) and has been widely adopted in various other domains. One of the key innovations of the Transformer model is the self-attention mechanism, which allows the model to weigh the importance of different parts of the input sequence dynamically.

```
Total Progress:   0%|          | 0/64 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001
```

```
Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]
```

```
Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=4, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01
```

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Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]
```

```
Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=32, num_heads=8, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001
```

```
Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=4, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]
```

```
Training with embed_dim=64, num_heads=8, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=128, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=128, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

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batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

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batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=128, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=256, rate=0.1, num_blocks=2,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01
```

```
Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=256, rate=0.1, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=256, rate=0.2, num_blocks=2,
batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

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batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

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batch_size=64, learning_rate=0.001, epochs=100, learning_rate=0.001

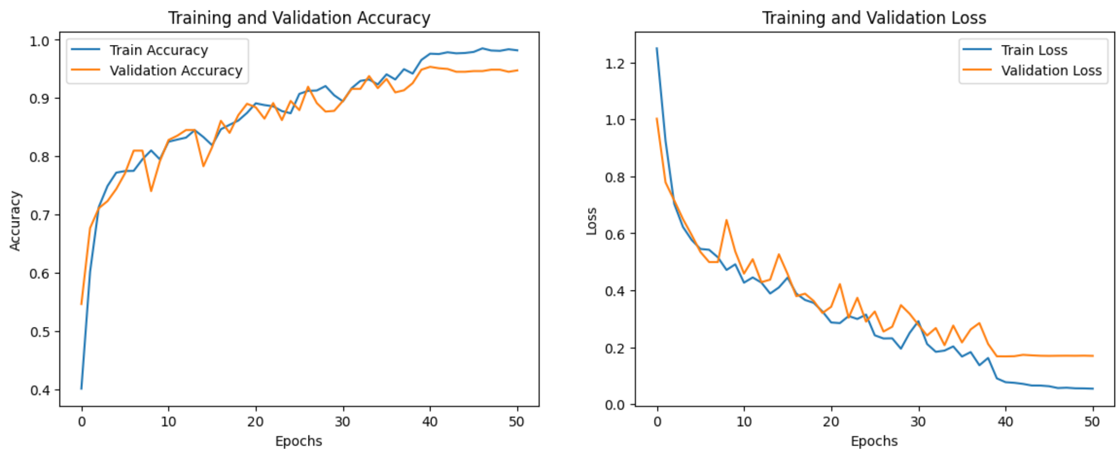
Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Training with embed_dim=64, num_heads=8, ff_dim=256, rate=0.2, num_blocks=3,
batch_size=64, learning_rate=0.01, epochs=100, learning_rate=0.01

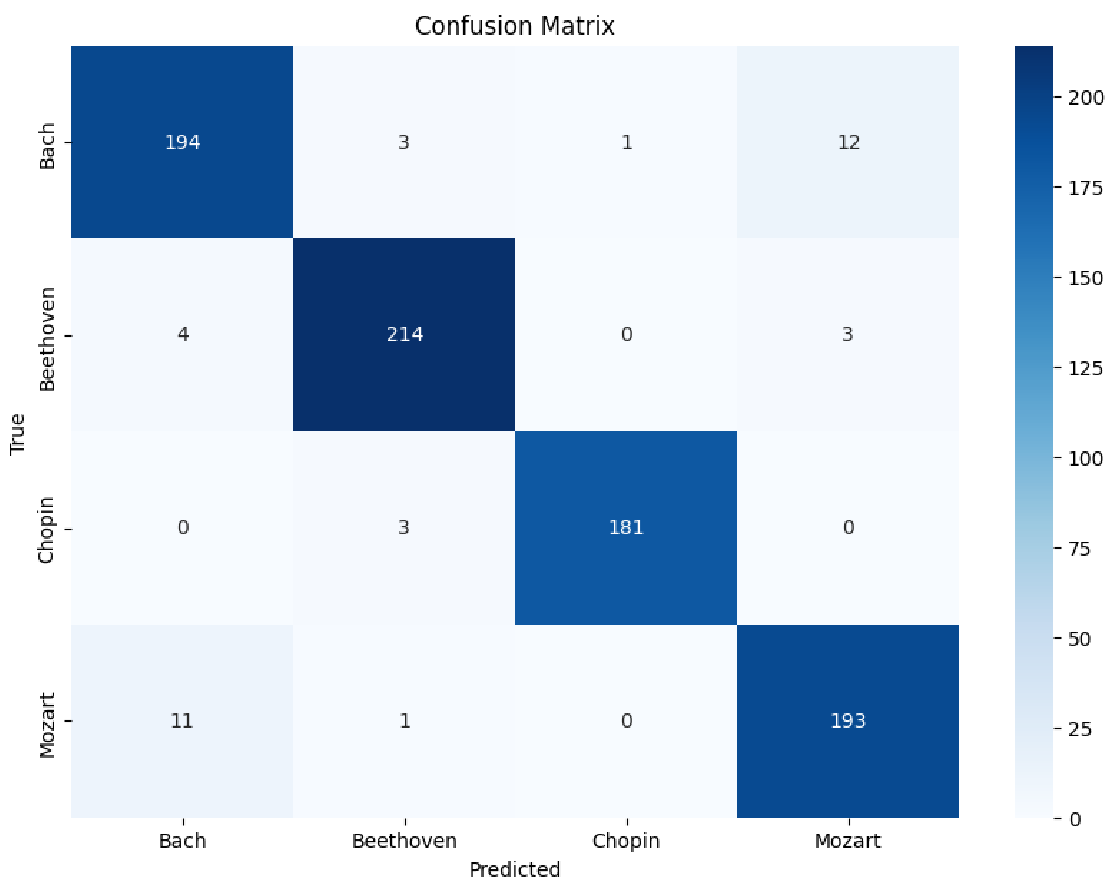
Training Progress :   0%|          | 0/100 [00:00<?, ?it/s]

Best Validation Accuracy: 95.37%

Best Parameters: (64, 8, 256, 0.2, 2, 64, 100, 0.001)
```




```
26/26                  6s 128ms/step
```




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

Bach	0.93	0.92	0.93	210
Beethoven	0.97	0.97	0.97	221
Chopin	0.99	0.98	0.99	184
Mozart	0.93	0.94	0.93	205
accuracy			0.95	820
macro avg	0.95	0.95	0.95	820
weighted avg	0.95	0.95	0.95	820