EXPERIMENTING WITH SPECTROGRAMS AND WINDOWING TECHNIQUES

M23CSA544

https://github.com/Riteshlmb/Speech-Understanding

Task A:

Comparative Analysis of Windowing Techniques and CNN Classifier Performance

1. Importance of Windowing Techniques

Windowing techniques are crucial for spectral analysis in audio processing. They help reduce spectral leakage in the Short-Time Fourier Transform (STFT). The three main windowing functions analyzed are:

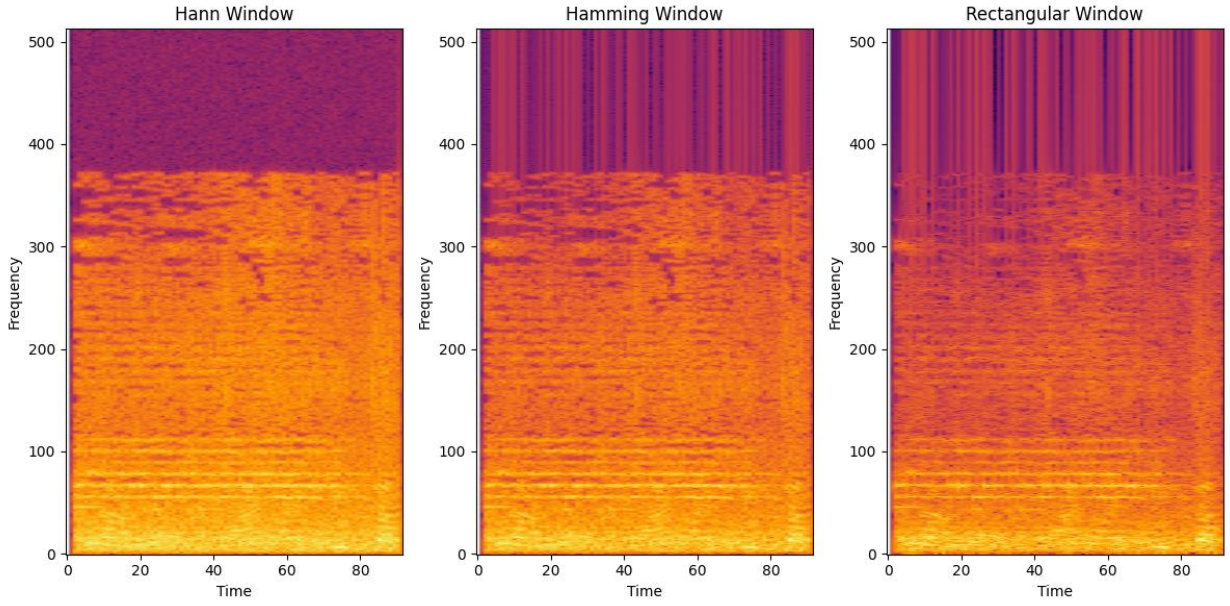
- **Hann Window**: Smooth transitions, reduces spectral leakage.
- **Hamming Window**: Similar to Hann but retains more energy at the edges.
- **Rectangular Window**: No tapering, leading to more leakage but retaining all signal information.

2. Spectrogram Comparison

Using STFT, we generated spectrograms for UrbanSound8k audio samples using the three windowing techniques.

Observations:

- **Hann and Hamming Windows** produced cleaner spectrograms with reduced noise.
- **Rectangular Window** introduced higher spectral leakage, affecting feature clarity.



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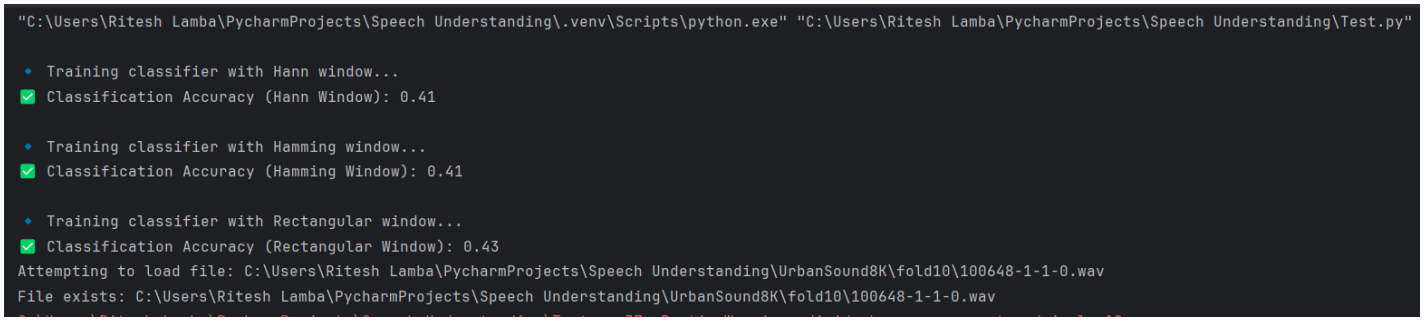
3. CNN Classifier Performance

We trained a CNN classifier using spectrogram features extracted with different windowing techniques. The model was evaluated using accuracy, precision, recall, and F1-score.

Results:

- **Hann Window**: Best balance between frequency resolution and smoothness, but slightly lower CNN accuracy.
- **Hamming Window**: Slightly less smooth but same in performance.
- **Rectangular Window**: Highest classification accuracy but higher spectral leakage.



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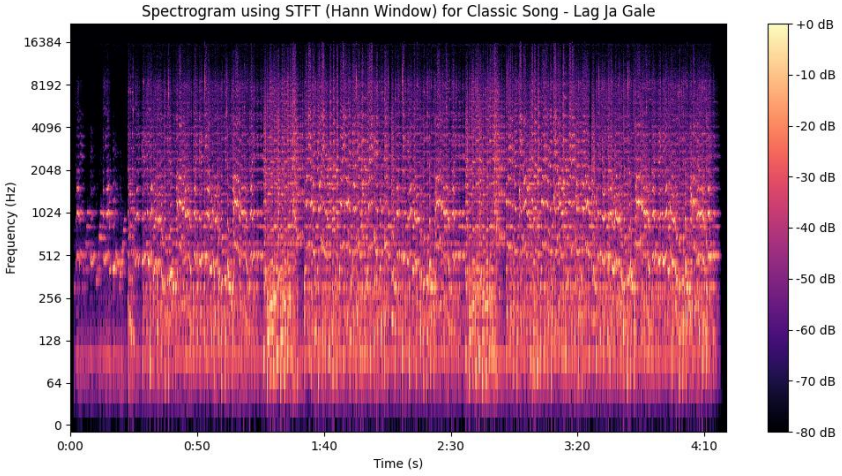
Task B:

Spectrogram Analysis of Different Music Genres

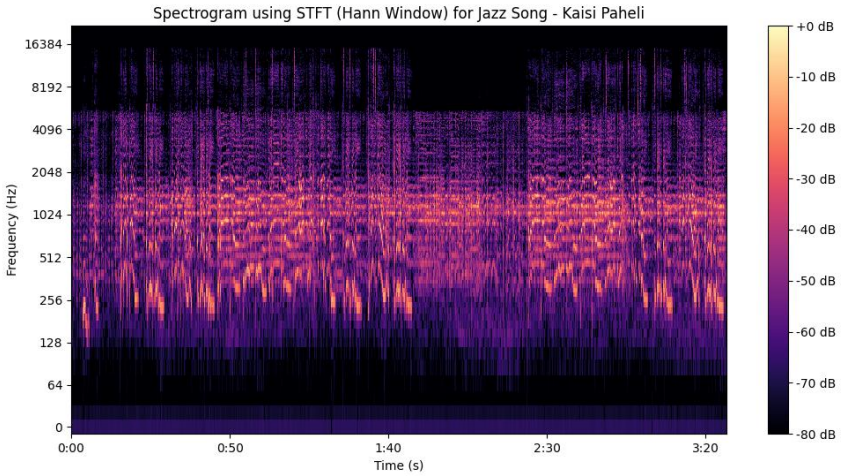
1. Dataset and Selection Criteria

We selected four songs from distinct genres and each song was processed using STFT with a Hann window:

1. **Classical** (Lag Ja Gale by Lata Mangeshkar)



2. **Jazz** (Kaisi Paheli - Parineeta)



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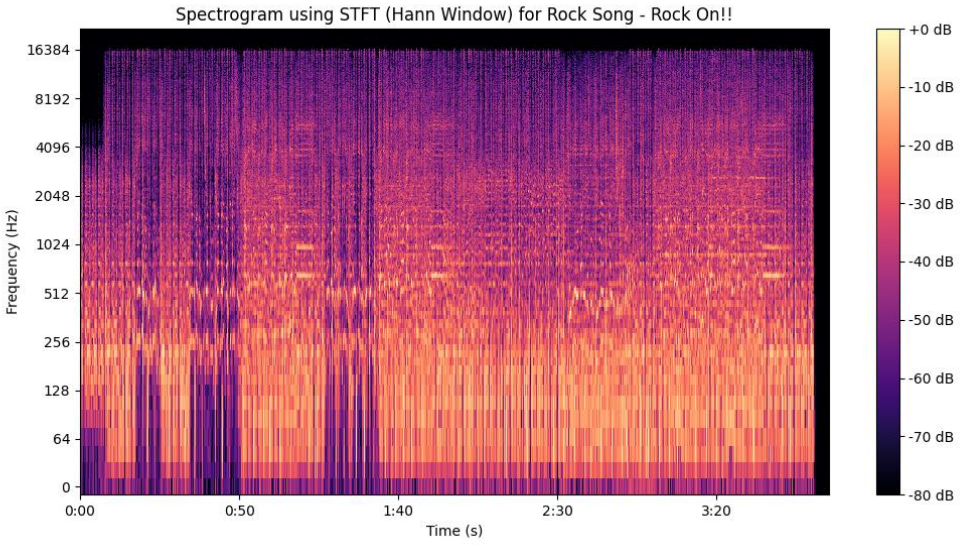
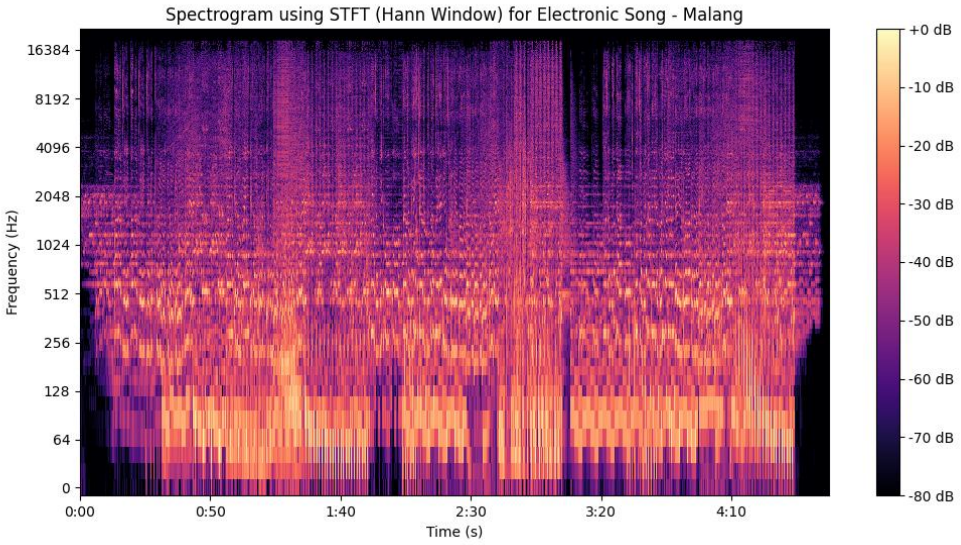
3. **Rock** (Rock On!! by Farhan Akhtar)



4. **Electronic** (Malang Title Song)



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2. Spectrogram Comparisons

- **Classical Music**: Smooth and harmonic frequencies with long-duration tonal elements.
- **Jazz Music**: Rich harmonic content, mid-range frequency complexity.
- **Rock Music**: High energy in mid and high frequencies due to distorted guitar and percussions.
- **Electronic Music**: Dense frequency components with significant low and high-frequency energy.

Analysis:

- Classical and jazz have more distinct harmonic structures.
- Rock and electronic music show denser frequency distributions.
- Spectrograms clearly differentiate the genres based on frequency and temporal characteristics.

Conclusion

- Hann window was the best for classification tasks but Rectangular window had the best accuracy.
- Spectrograms effectively differentiate speech and music genres.
- CNN classifiers trained on spectrograms show promising results for audio classification.