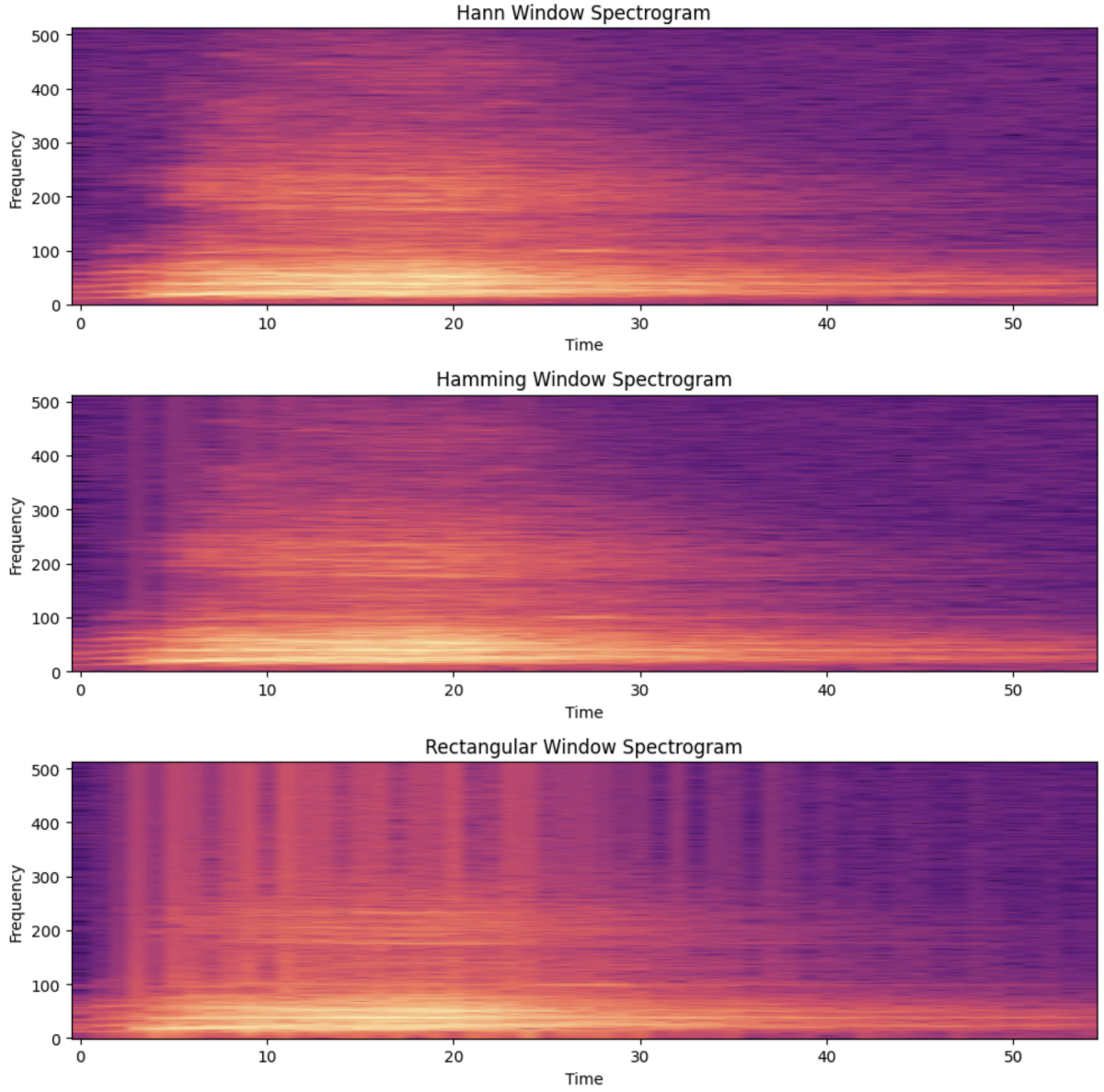
Analysis of Spectrograms Using Different Windowing Techniques

Pranjal Malik(M24CSA021)

The spectrograms shown in the image represent the same sound processed using **three different windowing functions**: **Hann, Hamming, and Rectangular windows**. Each window affects the spectral representation differently, influencing **spectral leakage, frequency resolution, and smoothness**.



Hann Window (Top Spectrogram)

- **Smoothest appearance** among the three.
- Less spectral leakage, with a gradual fade in higher frequencies.
- Broad main lobes but well-controlled side lobes.
- Best suited for **speech, music, and audio processing**.

Hamming Window (Middle Spectrogram)

- Similar to the Hann window but with **slightly sharper transitions**.
- Reduced spectral leakage compared to Rectangular, but not as smooth as Hann.
- Slightly better frequency resolution compared to Hann.
- Often used for **speech recognition and audio feature extraction**.

Rectangular Window (Bottom Spectrogram)

- **Most spectral leakage**, seen as **vertical stripes and more spread in frequency bins**.
- **Sharper edges and blocky artifacts**, indicating sudden transitions.
- Provides **best frequency resolution** but **worst leakage control**.
- Used when **high frequency resolution is needed but leakage is not a concern**.

Conclusion

- The **Hann window** is the best choice for **general audio processing** since it provides smooth transitions and controlled spectral leakage.
- The **Hamming window** is slightly sharper and is useful for **speech processing applications**.
- The **Rectangular window**, despite offering **better frequency resolution**, introduces **more spectral leakage**, making it **less ideal for audio applications** where smoothness is required.