

**ENHANCING PITCH DETECTION BY DEVELOPING METHODS OF  
TIME-FREQUENCY ANALYSIS**

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Time-frequency analysis is an indispensable technique for understanding the dynamics of signals over time, providing insights into instantaneous occurrences, temporal patterns, and hidden structures within complex data. In the present study, the methods of time-frequency analysis were used for a qualitative analysis of music signals. The Short Time Fourier Transformation (STFT) and Continuous Wavelet Transformation (CWT) were investigated for qualitative analysis of music signals. Digital Signal Processing (DSP) is vital in studying the accuracy of the conversion from analog signals to digital signals, minimizing potential errors that could be generated in the process. The primary contribution of this work was the introduction of a novel “Hann-Kaiser window” for the short-time Fourier transformation, which enhances pitch detection and reduces spectral leakage. This window combines the attributes of the Hann window and Kaiser window, resulting in better frequency resolution and reduced leakage compared to traditional windows. The efficiency of the modified window function was evaluated using specific parameters, including Signal-to-Noise Ratio (SNR), main-lobe width, and side-lobe suppression. The spectrograms revealed sharper pitch differentiation, particularly in harmonically rich regions of the signal, while the scalograms provided detailed insights into the transient features of the music signal. These visualizations demonstrated the Hann-Kaiser window’s ability to enhance the clarity of individual frequency components, making it easier to track pitch variations over time. The implementations of time-frequency representations were performed using Python, generating spectrograms and scalograms. Building on these results, future research directions could focus on integrating these time-frequency analysis methods into music signal processing workflows, further refining the accuracy of pitch detection.

**Keywords:** Hann-Kaiser window, Pitch detection, Signal processing, Spectrogram analysis, Time-frequency analysis