1. Introduction

This project builds a 13-filter IIR bandpass filter bank to detect musical notes from C4 to C5. Each filter targets a specific note, and the system identifies the input tone by analyzing the output energy. Notes are classified as exact match, detuned, or out of range.

1. Summary

I designed 13 IIR bandpass filters using the iirpeak function, each centered at a musical note from C4 to C5. The filter coefficients were defined based on normalized center frequency and a fixed bandwidth to ensure narrow and distinct frequency responses. Each signal was filtered through all 13 filters, and the output energies were computed and normalized.

I determine note status in two ways. The first one is to use FFT to capture the main frequency of the signal and compare it with the standard note frequency to categorize it. The second is to use a 13-band IIR bandpass filter to calculate the energy distribution of each note, and further categorize it by the ratio of the maximum energy to the Shannon entropy: when the maximum energy is concentrated and the entropy is low, the note is considered accurate, while if the energy is scattered or insignificant, the note is considered out of tune or out of range.

|  |  |
| --- | --- |
| Signal01.wav | Signal02.wav |
| 一張含有 文字, 螢幕擷取畫面, 繪圖, 行 的圖片  AI 產生的內容可能不正確。 | 一張含有 文字, 螢幕擷取畫面, 繪圖, 行 的圖片  AI 產生的內容可能不正確。 |
| Signal03.wav | Signal04.wav |
| 一張含有 文字, 螢幕擷取畫面, 行, 繪圖 的圖片  AI 產生的內容可能不正確。 | 一張含有 文字, 螢幕擷取畫面, 字型, 繪圖 的圖片  AI 產生的內容可能不正確。 |
| Signal05.wav | Signal06.wav |
| 一張含有 文字, 繪圖, 行, 螢幕擷取畫面 的圖片  AI 產生的內容可能不正確。 | 一張含有 文字, 螢幕擷取畫面, 繪圖, 行 的圖片  AI 產生的內容可能不正確。 |
| Signal07.wav | Signal08.wav |
| 一張含有 文字, 螢幕擷取畫面, 繪圖, 行 的圖片  AI 產生的內容可能不正確。 | 一張含有 文字, 螢幕擷取畫面, 行, 繪圖 的圖片  AI 產生的內容可能不正確。 |

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| --- | --- | --- | --- |
| Signal01.wav | Out of range | - | All filter energies very low |
| Signal02.wav | Detuned | C#4 | Energy spread, peak near C#4 |
| Signal03.wav | Exact Match | G4 | Peak energy at filter k = 7 |
| Signal04.wav | Out of range | - | All filter energies very low |
| Signal05.wav | Detuned | G#4 | Energy spread, peak near G#4 |
| Signal06.wav | Exact Match | C4 | Peak energy at filter k = 0 |
| Signal07.wav | Detuned | C5 | Energy spread, peak near C5 |
| Signal08.wav | Exact Match | A4 | Peak energy at filter k = 9 |

1. Conclusion

This project successfully implemented a 13-filter IIR bandpass filter bank to detect musical notes from C4 to C5 in unknown audio signals. By energy and FFT peak analysis, the system effectively classified tones as exact match, detuned, or out of range. The approach demonstrated reliable performance across varied input signals, showing that filter energy distribution and frequency domain features together provide a robust solution for musical note recognition.