**­­Assignment 3**

**Revisited: Fundamental Frequency Detection/Pitch Tracking**

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QA.3

For block size 1024, time resolution is block size/sample rate i.e., 1024samples/44100Hz =0.023 seconds and frequency resolution are ~43Hz. With the constraint of keeping the block size and sampling rate constant, one way to improve the frequency resolution would be zero padding. Zero padding increases the number of points thus we obtain a denser frequency grid when applying the Fourier transform.

QB.2

Estimated F0 using HPS, order =4

Chart

Description automatically generated

QE.1 Plots

1. Block size 1024, hop size 512
   1. FFT MAX: Estimated F0 and error

Chart, histogram

Description automatically generatedChart

Description automatically generated

Discussion:  As the frequency resolution is 43Hz, 441Hz and 882Hz are not accurate bin values in the spectrogram center frequencies. Hence, our estimates for the first half are ~430Hz and ~861Hz giving rise to the deviations of 11Hz and 20Hz respectively.

* 1. HPS: Estimated F0 and error

Chart

Description automatically generatedChart, histogram

Description automatically generated

Discussion: HPS algorithm relies on harmonics within a signal. However, in the current signal we have a pure sine tone with no harmonics. When the frequency in the signal reaches 882Hz, we observe that the algorithm detects a peak at the 1st bin (~43Hz) and then the third bin (~129Hz). Towards the end, the estimated frequency goes back to the ~43Hz and then to ~86Hz. It might have to do with the zero padding introduced in the last block by blockAudio function.

1. Block size 2048, hop size 512
   1. Estimated f0 and error: FFT MAX

Chart

Description automatically generatedChart, histogram

Description automatically generated

QE.2 Discussion: Upon increasing the block size, the error reduces and we only see a spike at the middle block (which has components from both 441 Hz and 882 Hz).

QE.3: Average performance metrics for ﻿FFT Max on the development set

rmsAvg: ﻿2547.40

pfp: 60.56

pfn: 0.37

QE.4 Average performance metrics for ﻿HPS on the development set

rmsAvg: ﻿2152.4

pfp: 91.88

pfn: 0.57

QE.6 Performance metrics for all three methods ACF, HPS and ACF with two values of threshold on the development set

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Method | Threshold | RMS Error | False Positives | False Negatives |
| ACF | -40 | **1081.86** | **17.45598431** | **0.67** |
| HPS | -40 | **1459.82** | **15.16192301** | **1.13** |
| MaxFFT | -40 | **2155.03** | **15.50675059** | **0.81** |
| ACF | -20 | **3398.32** | **0.139** | **34.796** |
| HPS | -20 | **3516.91** | **0.139** | **34.796** |
| MaxFFT | -20 | **3728.37** | **0.139** | **34.796** |