Single Phase Extraction Synthesis: Phase Dependent Isolated Oscillations

1st Edition

Digital Down

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Abstract

Single Phase Extraction Synthesis is a separate type of Extraction Synthesis that separates and processes individual phases of an audio waveform.

1 Introduction

Extraction Synthesis, as introduced in previous work [1], is a technique that isolates individual oscillations from audio inputs by analyzing raw audio data at the sample level. Single Phase Extraction Synthesis extends this concept by focusing on specific phases of the audio waveform. Samples are scanned for either positive or negative values, depending on the chosen phase. A key difference in Single Phase Extraction Synthesis is that the expected oscillation count for each note is halved. This adjustment accounts for considering only one phase of a complete waveform.

2 Methodology

2.1 Oscillation Identification

Single Phase Extraction Synthesis scans the list of sample values to identify complete single-phase oscillations. An oscillation is defined as a sequence of sample values that starts and ends with a zero crossing, containing only positive or only negative values, depending on the chosen phase.

Let S be the set of sample values $\{s_1, s_2, ..., s_n\}$

A positive phase oscillation O_p is defined as a subsequence of S where:

$O_p = \{s_i, s_{i+1}, ..., s_j\}$ where $s_i \geq 0, s_j \geq 0,$ and $\forall k : i < k < j, s_k > 0$

A negative phase oscillation O_n is defined as a subsequence of S where:

$O_n = \{s_i, s_{i+1}, ..., s_j\}$ where $s_i \leq 0, s_j \leq 0,$ and $\forall k : i < k < j, s_k < 0$

The algorithm tracks a single counter:

- Phase Count: The number of consecutive samples in the chosen phase

When a complete single-phase oscillation has been scanned, the algorithm checks if an accepted sample sequence has occurred.

2.2 Note Frequency Matching

For each identified oscillation, the total sample count (Phase Count) is compared to half the expected sample count for each musical note. The expected sample count for a note is calculated as follows:

$$\text{Expected Phase Count} = \text{Round}\left(\frac{\text{Round}(\frac{\text{Sample Rate}}{\text{Note Frequency}})}{2}\right)$$

Where:

- Sample Rate = 44100 Samples Per Second
- Note Frequency is in Hz

For example, for the note A4:

- A4 Frequency = 440 Hz
- Expected Sample Count = Round(44100 / 440) = 100
- Expected Single-Phase Count = Round(100 / 2) = 50

2.3 Phase Adjustment

After processing, the extracted oscillations are adjusted based on the chosen phase:

- For positive phase: All sample values are made positive using absolute value.
- For negative phase: All sample values are made negative using negation of absolute value.

2.4 Note Frequency Tables

The following tables list all the notes considered in the current implementation, along with their frequencies and expected oscillation counts (halved for single-phase extraction):

Note	Frequency (Hz)	Expected Oscillation Count
	Octave 1	
C1	32.70	674
C#1/D♭1	34.65	637
D1	36.71	601
D#1/E♭1	38.89	567
E1	41.20	535
F1	43.65	505
F#1/G♭1	46.25	477
G1	49.00	450
G#1/A♭1	51.91	425
A1	55.00	401
A#1/B♭1	58.27	379
B1	61.74	357
	Octave 2	
C2	65.41	337
C#2/D♭2	69.30	318
D2	73.42	301
D#2/E♭2	77.78	284
E2	82.41	268
F2	87.31	253
F#2/G♭2	92.50	239
G2	98.00	225
G#2/A♭2	103.83	213
A2	110.00	201
A#2/B♭2	116.54	189
B2	123.47	179

Table 1: Note Frequencies and Expected Oscillation Counts - Octave 1 and 2

Note	Frequency (Hz)	Expected Oscillation Count
	Octave 3	
C3	130.81	169
C#3/D♭3	138.59	159
D3	146.83	150
D#3/E♭3	155.56	142
E3	164.81	134
F3	174.61	127
F#3/G♭3	185.00	119
G3	196.00	113
G#3/A♭3	207.65	106
A3	220.00	100
A#3/B♭3	233.08	95
B3	246.94	90
	Octave 4	
C4	261.63	85
C#4/D♭4	277.18	80
D4	293.66	75
D#4/E♭4	311.13	71
E4	329.63	67
F4	349.23	63
F#4/G♭4	369.99	60
G4	392.00	57
G#4/A♭4	415.30	53
A4	440.00	50
A#4/B♭4	466.16	48
B4	493.88	45
	Octave 5	
C5	523.25	42
C#5/D♭5	554.37	40
D5	587.33	38
D#5/E♭5	622.25	36
E5	659.25	34
F5	698.46	32
F#5/G♭5	739.99	30
G5	783.99	28
G#5/A♭5	830.61	27
A5	880.00	25
A#5/B♭5	932.33	24
B5	987.77	23

Table 2: Note Frequencies and Expected Oscillation Counts - Octaves 3, 4, and 5

2.5 Optional Parameters

2.5.1 Audio Normalization

To optimize the extraction process, it is ideal to normalize the input audio in situations where the audio input is too quiet. The normalization process involves the following steps:

1. Find the maximum absolute value in the audio samples.
2. Divide all samples by this maximum value.
3. Multiply the result by the maximum possible absolute value for 16-bit audio (32767).

$$s'_i = \frac{s_i}{\max(|S|)} \cdot 32767$$

Where $\max(|S|)$ is the maximum absolute value in the original sample set.

2.5.2 Maximum Amplitude Threshold

Similar to the original amplitude threshold outlined in the original Extraction Synthesis research, the average absolute values in an oscillation must not exceed the maximum average absolute threshold.

$$\text{Average Absolute Value} = \frac{\sum |s_i|}{n}$$

(s_i are the samples in the oscillation and n is the number of samples)

2.5.3 Methylphenathylamine

Methylphenathylamine is an audio time stretching technology and is used in Extraction Synthesis in situations where audio input is typically too short or for any other reason where less oscillations are accepted. There are two operations that are used called M-Slow and M-Fast.

- M-Slow: Doubles the audio input time allowing for oscillation captures that are half of the typical accepted oscillation's sample count.
- M-Fast: Halves the audio input time allowing for oscillation captures that are double the typical accepted oscillation's sample count.

3 Conclusion

As a type of Extraction Synthesis, Single Phase Extraction Synthesis intends to create sounds that would not be possible in the traditional Extraction Synthesis method.

References

[1] Digital Down. (2024). Extraction Synthesis: Audio Synthesis Through Oscillation Isolation. 1st Edition.

Further Research

Further research is currently being done to separate phases further into Beta+ and Beta- Phases within a corresponding individual phase. This will allow even more diverse kinds of sounds that Extraction Synthesis is able to create.