

Abstract

The string orchestra sound is intricately layered with countless frequencies due to natural pitch imperfections and complex overtones that help to shape the timbre of the string sound. This phenomenon has challenged accurate digital replication of orchestral sounds. In this study, we utilized the multi-oscillator waves from the Thor Polsonic synthesizer, detuned the sound by different amounts, and measured and analyzed it using frequency spectra in Audacity software. Our study suggests that a detune amount of 20 most accurately mimics the sound of a string orchestra, as detuning amounts higher than 20 exhibited a more dissonant and out-of-tune sound.

Keywords

Synthesizer: An electronic muscial instrument.
Oscillator: An algorithm in a synthesizer that generates a raw periodic waveform.
Detune: Fractional pitch shifts in an audio.
Digital Audio Workstation (DAW): A software used to produce audio files.
Sawtooth Waves: A non-sinusoidal waveform that resembles the teeth of a saw.

Multi-Oscillator Detuning to Mimic Orchestral String Sound

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Introduction

Synthesizers are instruments that produce sounds electronically. Although synthesizers could be used to formulate sounds many acoustic instruments cannot, it is a challenge to synthesize a sound of a string orchestra because of its complex frequency variations and unique harmonic characteristics. Therefore, we investigated how the degree of detuning, or slightly altering the frequency of the sound, affects the frequency spectra and how closely the detuned sound can resemble string orchestra. We hypothesized that detuning multiple sawtooth waves would produce a frequency spectrum similar to string orchestra while fine detuning to bring the synthesized sound closer to the natural richness of a string orchestra.

Methods

For our methodology, we tested if detuning multiple sawtooth oscillators could copy the sound of an orchestral string section. Using Reason 13 as our digital audio station, the NN-XT String Orch present as a reference (Fig. 1), and the Thor Polysonic Synthesizer for our test sounds (Fig. 3), we reset Thor and changed its analog oscillator to a multi-oscillator with sawtooth waves (Fig. 3). This waveform contains many harmonics, similar to the tone of bowed strings. Keeping the envelope settings constant, the Attack was 0, Decay was 705 milliseconds, Sustain was full, and the Release was 423 milliseconds. We used random 1 detune mode. Our independent variable was detune amount, testing values of 0, 10, 20, and 30. We then analyzed each sound in Audacity using frequency-spectrum analysis and compared the harmonic patterns to the string-orchestra reference.



Figure 1: String orchestra device



Figure 3: Default setting of Thor in Reason 13.

Results and Discussion

Single Sine Wave: Decreases gradually and relatively uniformly from the lower frequency bins to approximately bin 55,000 (Fig. 2). Afterwards, the spectrum remains relatively stable with reduced variation in magnitude.

Orchestra Spectrum (Reference): Exhibited a less uniform spectral decrease. The magnitude of the repeated peaks varied more randomly, and the random variation peaks disappeared at 51,494 frequency bins (Fig. 2). At higher frequency bins, the orchestra spectrum also showed broader spread in magnitude.

Since an orchestra is a combination of many string instruments, there must be constructive and destructive interference, which produce variations in spectral magnitude, resulting in a less uniform spectrum than the single sine wave.

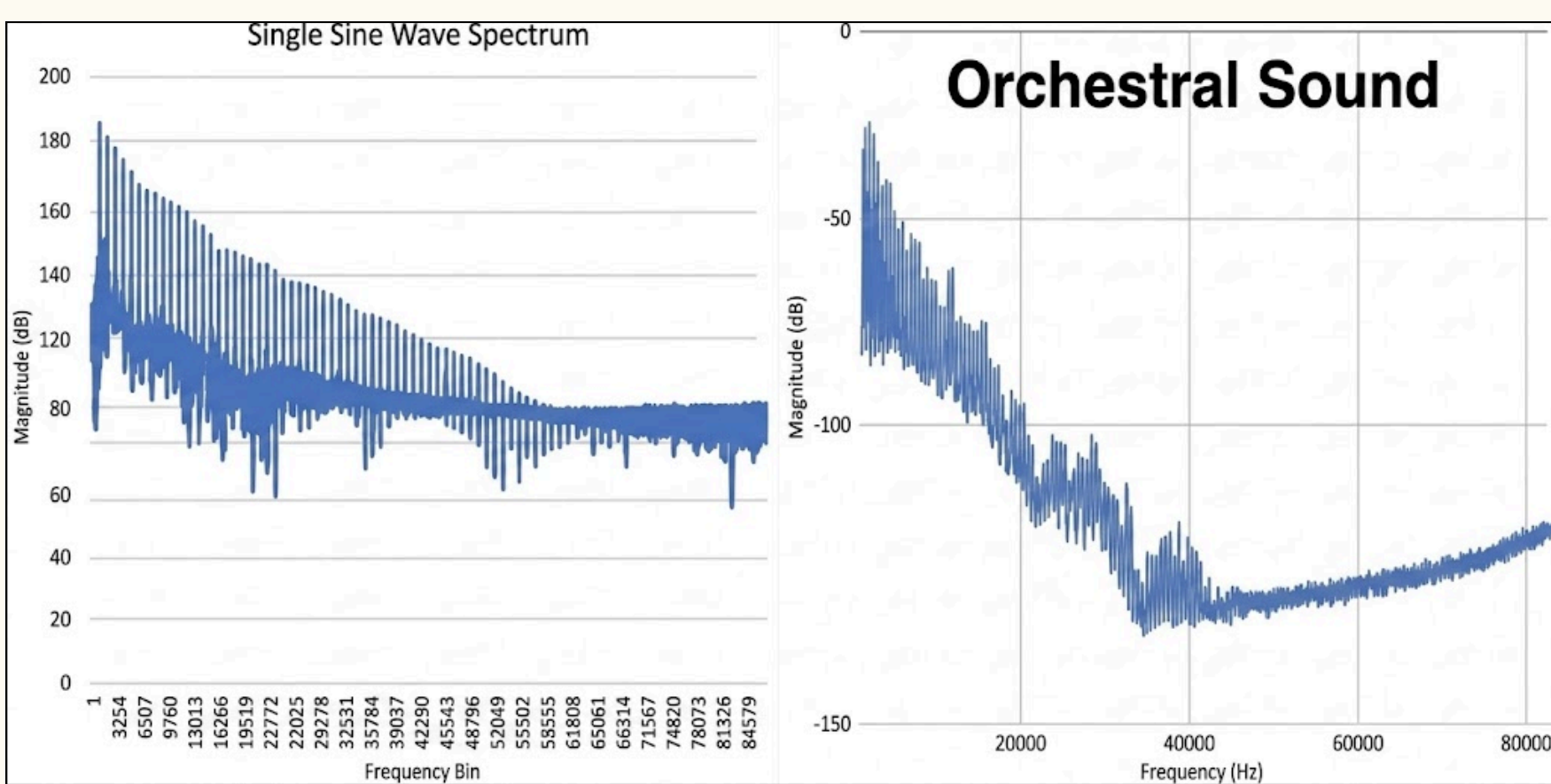


Figure 2: Comparison of single sine wave spectrum vs orchestra sound spectrum from NN-XT.

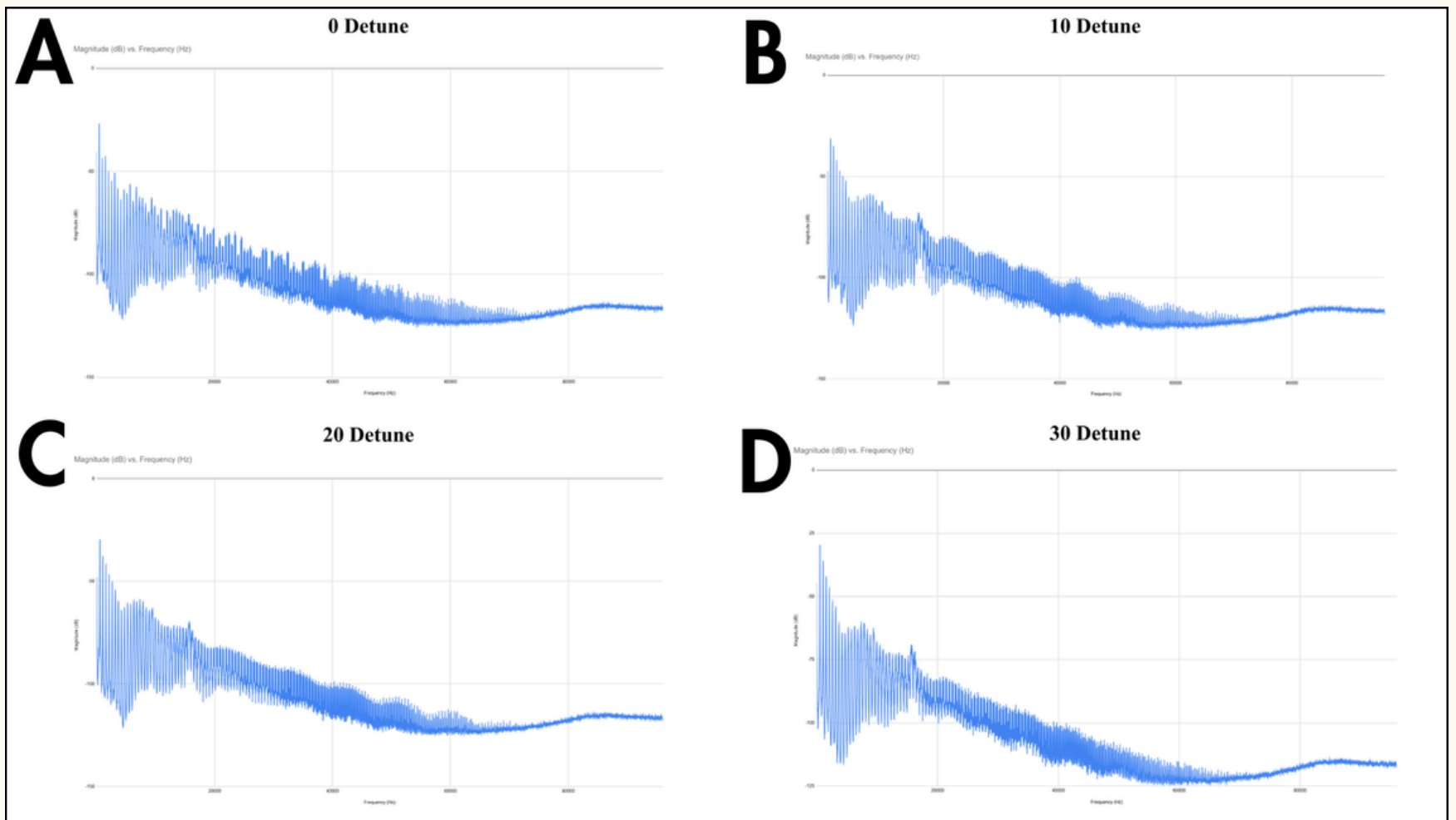


Figure 4: Multi-Oscillator Detune Spectrum.

Detune 0: Oscillators occupy nearly the same frequencies, making harmonic peaks appear comparatively regular (Fig. 4).
Detune 10: Small frequency offsets begin to broaden the harmonic structure and bring amplitude variation.
Detune 20: The spectrum becomes more dense and irregular as the harmonic components from the individual oscillators separate.
Detune 30: More noticeable separation, with broader distribution of spectral energy and greater variation between neighboring peaks.

Although detuning makes multi-oscillator sounds more orchestra-like, detune levels past 20 causes the sounds to become too separated. This causes stronger beating, pitch instability, and greater harmonic mismatch among oscillators. So, we decided to keep 20 as our best detuned target sound. By using muti-oscillators and the detuning effect, we were able to create similar sound compared to orchestra.

Limitations to this study include individual judgement natural or unpleasant sound, as some might say it was excellent or too synthetic. Moreover, this study mainly compared the frequency spectra; however, there are other important characteristics of orchestral sound that were omitted omitted for sound purposes only.

Conclusion

Our results showed that a multi-oscillator synthesizer with detuning can produce a sound that closely resembles orchestra sound. A detuning value of 20 produced the best result, while higher detuning caused excessive beating, pitch instability, and harmonic imbalance. Therefore, our experiments showed that our hypothesis was correct. We recommend that further studies include other factors such as ADSR ranges, and choir effect, as the effect of the sound varies per individual.

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