Real Time Counterpoint Synthesizer

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Karaoke and Beyond

Ideal Karaoke Experience

What’s missing?

Every time you sing a song the background is the same!
Almost insurmountable difference between a karaoke singer and a trained musician

Creating music is hard
Even musicians can struggle with composition
Years in music theory classes
General Goals

Audio In (Melody)

Counterpoint Synthesizer

Audio Out (Melody)

Audio Out (Counterpoint)
FFT

- 2048 Point
- 9.6kHz samples (1 in 5 from AC97)
- 1 Input: 8 bit audio from AC97 module
- 3 Outputs: FFT 8 bit index, real coefficient, imaginary coefficient
Pitch Finder

- Input: 8 bit FFT real coefficient (re), imaginary coefficient (im), index
- Find FFT magnitude = $\sqrt{re^2 + im^2}$
- 2 clock cycle delay
- Remember largest magnitude and matching index
- After all 2048 samples pass through the FFT, compare the saved largest magnitude’s index to pitch lookup table, output closest note

Figure 3. Pictorial model of frequency lookup table
Counterpoint FSM

First Implementation:
1. Only Major Counterpoint intervals allowed (6 in all)
2. 12 possible next notes

Second Implementation:
1. Major and Minor Counterpoint intervals

Melody Interval: M2 (-1)

Counterpoint Interval
State = 5

Next Counterpoint Interval
State = 3
Examples of State Transitions

- M3 (-2)

- M2 (-1)

- M4 (-3)

- M5 (-4)
Tone Generator

- Time Domain Pitch Shift
- Inputs: 8 bit audio from filters, shift interval
- Interval shift is *relative*; therefore output should always sound correct
- Alphas dependent on intervals
- 2 Dual BRAMs
Equalizer

- Attenuate unwanted frequencies
- Boost desired frequencies
- 5-band, centered around 100Hz, 300Hz, 1KHz, 3KHz, 10KHz
Reverb, Distortion

- Reverb adds delayed, attenuated copy of signal to output

- Distortion (overdrive) applies gain to signal, then artificially clips it
Timeline

11/15: FFT module completed, memory allocated, Pitch Finder built

11/22: Effects filters built and tested in Matlab, on FPGA, Pitch Finder tested

Counterpoint Module built and tested

11/29: Tone Generator, UI

12/6: Module Integration