ColorSynth: An Audiovisual Tool for Understanding Harmonic Ratios

Rountree E. (ehrount15@earlham.edu)
Earlham College Department of Computer Science, 2019

Introduction

- ColorSynth is a program created to visualize the harmony of musical intervals. The design architecture of this program is shown in Figure 3. ColorSynth uses real-time user input of up to two simultaneous notes from a MIDI keyboard to create a visualization representing the harmonic quality of any played interval. The objective was to create a visualizer in which consonant and dissonant intervals are clearly visually distinct.
- There are two experimental variations used to compare and evaluate the effectiveness of different visualization methods.
- Two different color mappings are used to distribute the RGB color spectrum to different notes. The chromatic mapping organizes the colors so that the closer notes are on the keyboard, the closer they are on the color spectrum. The fifths mapping organizes the colors so that notes separated by a perfect fifth are closest on the color spectrum. Both mappings are shown in Figure 1.
- The other variation is the spatialization method used for scaling the size of the sine wave oscillations. The frequency method scales the spatialization relative to the frequency of the note it's representing. The ratio based method scales each note's spatialization relative to the interval ratio using a just intonation tuning shown in Figure 2.

Design Architecture

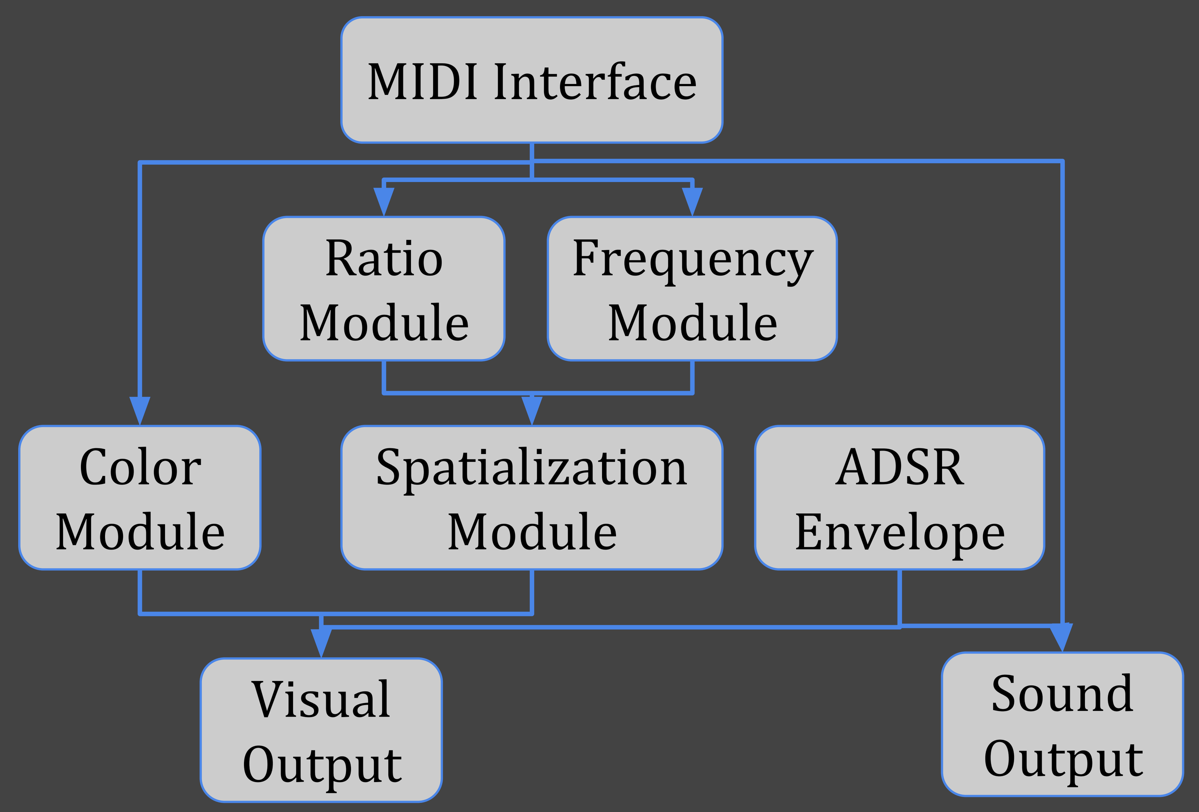

Figure 3: Design Architecture of ColorSynth

Color Mappings

Note	Chromatic color mapping	Chromatic RGB value	Fifths color mapping	Fifths RGB value
C		1,0,0		1,0,0
C#/Db		1,.5,0		0,.5,1
D		1,1,0		1,1,0
D#/Eb		.5,1,0		.5,0,1
E		0,1,0		0,1,0
F		0,1,.5		1,0,.5
F#/Gb		0,1,1		0,1,1
G		0,.5,1		1,.5,0
G#		0,0,1		0,0,1
A		.5,0,1		.5,1,0
A#/Bb		1,0,1		1,0,1
B		1,0,.5		0,1.5

Figure 1: Two variations in color mappings

Interval Ratios

Interval	Just Intonation Frequency Ratio[1]	Dissonance Value
Minor Second	15:14	29
Major Second	9:8	17
Minor Third	6:5	11
Major Third	5:4	9
Perfect Fifth	4:3	7
Diminished Fifth	10:7	17
Perfect Fifth	3:2	5
Minor Sixth	8:5	13
Major Sixth	5:3	8
Minor Seventh	7:4	11
Major Seventh	15:8	23
Perfect Octave	2:1	3

Figure 2: Interval Ratios and Dissonance

Results

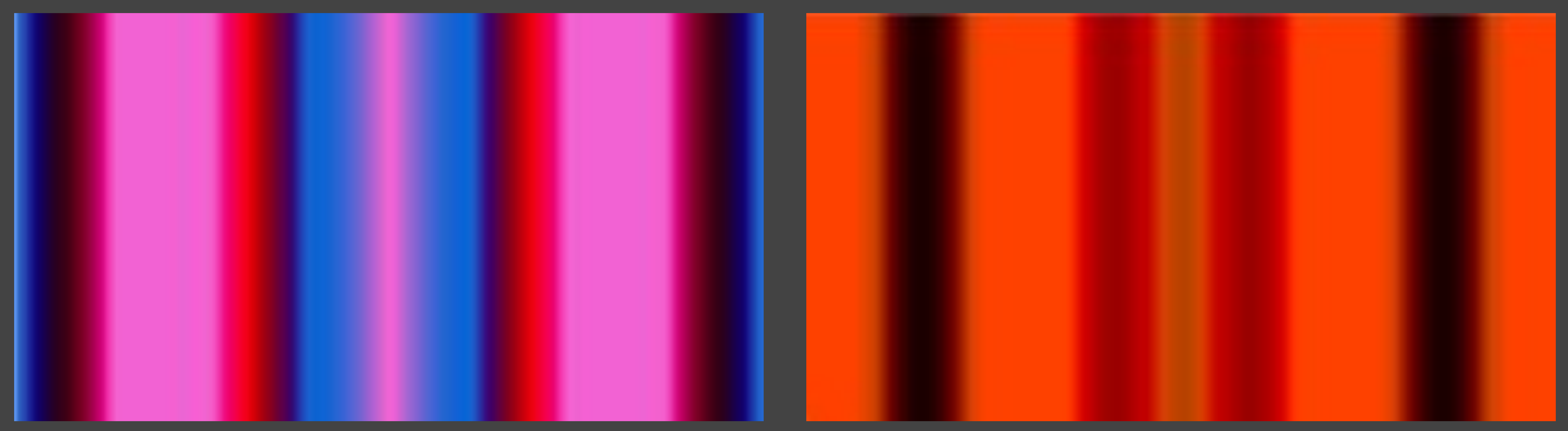

Figure 4: A perfect fifth played with two different color mappings (left: fifths mapping, right: chromatic mapping)

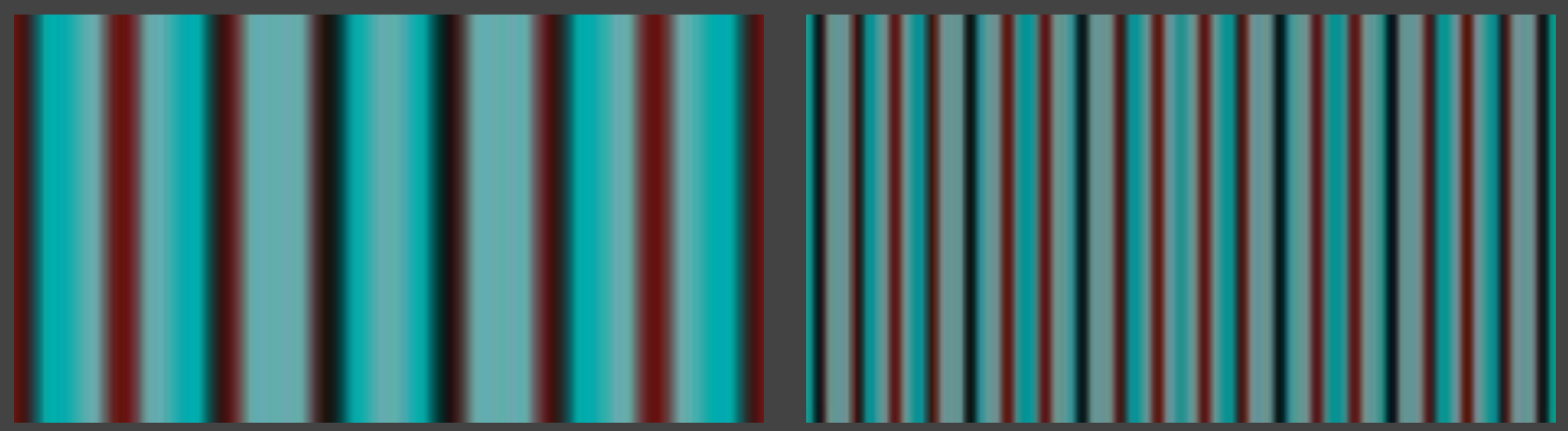

Figure 5: A diminished fifth played with two different spatialization methods (left: frequency method right: ratio method)

Evaluation

- Figure 4 shows a perfect fifth interval consisting of C and G played using the two variations in color mapping. In the fifths color mapping C is represented with red and G with orange. The areas where the notes overlap becomes a red-orange color. In the chromatic color mapping C is represented with red and G with blue. The areas where the two notes overlap becomes a shade of purple. A perfect fifth is a highly consonant interval with a dissonance value of 5.
- Figure 5 shows a diminished fifth composed of a C and a Gb played using the two variations in spatialization methods. The diminished fifth is a very dissonant interval with a dissonance value of 17. The ratio method shows this dissonance by showing oscillations relative to its dissonance value. The frequency method doesn't clearly distinguish between dissonance and consonance but can distinguish between the same note in different octaves.

Conclusion

- After evaluating the color combinations of all the the intervals, my research determined that the fifths based mapping system did a better job showing distinctness between consonant and dissonant intervals than the chromatic based mapping. In the fifths based system consonant intervals are composed of related colors and dissonant intervals are composed of distinct colors.
- Both spatial variations have some advantages but the ratio based method is better at showing consonance and dissonance distinctness
- The most similar project working on visualizing music with attention payed to harmonic ratios was conducted by Mathias Lehnfeld. His approach does not use color and uses a visualization technique derived from oscilloscopes by assigning frequencies to the x and y axes.[1]
- Other similar works used music visualization as a way to convey musical feeling to people with hearing impairments[2]

Future Work

To get ColorSynth finished the main next step is to fix a bug in the spatialization updater for the ratio module that creates excessive latency. In future work on this subject, this visualization method could be applied to a program that does not have a limit of two simultaneous notes. It would also be possible to use a tool for analyzing an audio signal for the most prominent frequencies and use that for input as opposed to a MIDI interface.

References

[1]M Lehnfeld, **Eden: Visualization Techniques and Sound Synthesis based on Oscilloscope Art**, Masters Thesis in Sound design, University of Music and Performing Arts Graz, 2017 pp.1-53
[2]S Nanayakkara et. al., **An enhanced musical experience for the deaf: design and evaluation of a music display and a haptic chair,** Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2009 pp. 337-346

Acknowledgements

I would like thank all the people who helped me in the process of executing and researching this project. Xunfei Jiang and David Barbella in the Earlham College Computer Science Department helped guide me in the process of developing my idea and overcoming obstacles. Forrest Tobey from the Earlham College Music Department was an important resource for advice regarding computer music tools and music theory questions.