VOCAL HARMONIZER: REAL-TIME HARMONIZATION USING FREQUENCY IDENTIFICATION AND AUDIO SIGNAL MANIPULATION

(Technical Paper)

AN INVESTIGATION OF THE SOCIAL BENEFITS OF MUSIC EDUCATION

(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

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Spring, 2021

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

My technical work and STS work will be focused on the area of music. For my technical project, my group and I will be focused on creating a device to allow harmonizing with one's self. With my STS research, I will research the connection between an individual's exposure to music and the impact on their social skills [1].

For my technical topic, my team and I will be creating a vocal harmonizer, which allows a user to sing or play an instrument into a microphone. The user will simultaneously be playing notes on a connected keyboard, which will be connected to our main processing system. The system will then process the signals and output the user's voice at pitches played by the user on the keyboard.

The idea of researching the impact of music on social development came from the realization that during a global pandemic, musical education has become a very low priority for education systems, due in part to the difficulty of teaching music virtually. It was this realization that drove my interest in learning more about the long-term impacts that this could have on our society, including future social problems for current students. This led to my decision to research the connection between music education and the development of social skills.

By creating a musical device while studying the societal impacts of music, I hope to gain a greater understanding of how music can influence our society and the people in it.

Technical Project Description

Our project to create a vocal harmonizer came from the realization that during the COVID-19 pandemic, musical groups are no longer able to practice or perform together. The device synthesizes vocal audio from a microphone with user-played chord input from a

keyboard. The user will be able to play the desired chord on the keyboard while singing any note they choose into the microphone, and the speaker will output the voice reharmonized into the chosen chord. This device may benefit musical education and will also allow a user to at least gain a small sense of togetherness, even when they are forced to perform music alone. As the user does not need to sing one of the notes in the chord, the vocal harmonizer device would eliminate the limitations of individual vocal range and assist in the method Spies [2] proposed for teaching harmony through "active experimentation." This project will mostly serve as a learning exercise for our group, but we believe that the idea could be applied to today's difficult learning environment.

As stated previously, this project will serve as a hands-on tutorial for our group. There are many separate portions of this project that involve collaboration, technical skills, and expertise with specific tools. From this project, we expect to gain a better understanding of digital signal processing, circuit board design and construction, embedded system analysis, and programming microcontrollers.

The harmonizing approach begins with an audio signal input via the microphone. This signal travels through an anti-aliasing filter on the PCB to minimize noise in the signal. Then, the filtered audio is inputted into the codec, which converts it to a 16-bit digital signal. The digitized voice signal is then fed from the PCB into the myRIO embedded device via serial communication. The keyboard audio input is digitized and communicated to the myRIO by the same process.

Digital signal processing occurs on the myRIO as follows. The keyboard signal is translated into a set of frequencies representing the chord that is played, using either an FFT or

cepstral analysis. The voice signal is translated from the time domain to the frequency domain using an FFT. This frequency representation is used to identify the fundamental frequency of the voice signal. The frequency-domain voice signal is then shifted from its fundamental frequency center to each of the keyboard frequencies in the set, and all of those signals (one per keyboard note) are added together into a unified, frequency-domain, chordal output signal. This signal is then converted back to the time domain with an IFFT.

The digital output signal is sent from the myRIO back to the codec via serial communication. The codec converts the signal back to analog. The analog signal may need to be buffered on the PCB before going to the piano amp. Finally, the amplified output signal is fed into a speaker, which plays the desired output audio. The block diagram representing the flow of the audio signal within the system is shown in Figure 1.

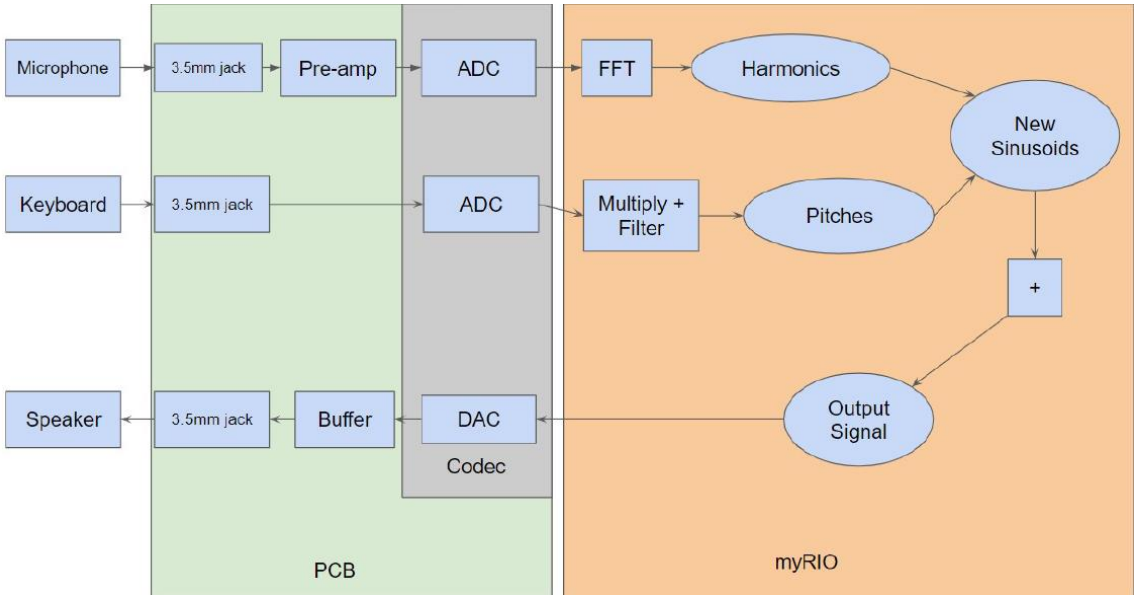

Fig. 1. Block Diagram of Vocal Harmonizer. Full block diagram illustrating the signal path from the inputs through the PCB and myRIO to the piano amp (Created by Noah Mills, 2020).

To complete this project, we have designed circuitry to connect our user inputs and outputs to our processing unit. Using software tools, we were able to design the system and perform tests to confirm that it should work as we planned. The $500 budget for the project was provided by the School of Engineering and Applied Sciences. After we assemble the system, we will do the majority of testing in the National Instruments (NI) laboratory in the C-Wing of Thornton Hall. The NI laboratory provides the soldering equipment for connecting components to the PCB and the VirtualBench needed to test signals and voltage readings. Testing the vocal harmonizer together in the lab will allow us to collaborate and measure the effectiveness of the system with different voice ranges in a controlled environment.

Due to this semester's unique schedule, we plan to have this project completed no later than the end of November 2020. Our technical advisors are Harry Powell and Adam Barnes, who are both professors in the Electrical and Computer Engineering Department.

STS Topic

My STS research will examine the impacts that exposure to music can have on the development of social skills. I hope to answer the following question: Is there a significant effect on the development of social skills in adolescents that results from exposure to music? I believe that this is an important topic in today's society, because so much of education is dedicated to science, technology, engineering, and math - otherwise known as STEM. While I believe STEM is important, I believe it is equally important to research the positive effects of music education and exposure that contribute to a well-rounded individual. According to Hallam [3], "the development of particular musical skills will have a direct influence on brain development".

Research specifically on the topic of music's impact on social skills is available, but most papers on this topic focus specifically on children with intellectual disability. Specifically, I plan to research the effects of music on neurotypical children and adolescents. This will require me to meta-analyze other research papers about similar subjects and compile information about my specific research question [1]. I will also investigate articles specifically written by music educators on the impact of STEM education on music programs [4]. This research will help me understand the current situation in the world of music education. Additionally, I will research the available music education technologies available to teachers and students and analyze the current state of music education during the pandemic. This will allow me to create a more complete picture of the current state of music education.

By researching both the effects of music education and the impact of STEM education of music programs, I will establish a link between the declining condition of music education and the detriments to social development that are being caused by it. This research is increasingly relevant as the pandemic-caused shift to virtual learning has caused a decrease in the quantity and quality of music education for students. By the time I conclude my research, I hope to be able to confidently connect the decrease of music education with a decrease in social development.

Conclusion

The connection of STEM education and music education is often overlooked. By researching the impact of music education and its social values, I will determine the impact that increased STEM education, and therefore decreased music education, has on students socially. My STS project will be loosely coupled with my technical project, as they both pertain to music. However, there are many differences in both scope and public perception. I will learn about the

mechanics of creating music from my technical project, and the societal and psychological impacts of music from my STS research.

References

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