Digital Mimicry: A Sonically Neutral Comparison Between Guitar Amplifiers and IR-Based Emulation

Participants

Student – Sage Rice

Mentor – Seth Shafer

Project Description

Research Subject

The research will focus on a sonically neutral comparison between real guitar amplifiers/cabinets and digital recreations of the same amplifiers and cabinets. The method of physical modeling being used is (FIR) finite impulse response filters. These filters are commonly used to mimic spaces or equipment to increase auditory options while saving time and money.

Research Process

First, selected cabinet and amplifier combinations will be captured using the university owned Earthworks TC30k microphone and a Fractal Audio Axe FX III's IR capturing method as well as a DIY method using Reaper's ReaVerb to compare IR convolution price points. The process used to capture IR filters involves playing a sweeping sine wave through the amplifier and cabinet and recording a .wav file, capturing the characteristics of the combination as well as any characteristics of the room and microphone with it. To negate any potentially odd frequencies created by the room, microphone, or FRFR (full-range, flat-response) IR playback speaker these three things will be captured in the exact same position as the rest of the amplifiers and cabinets, and the resulting IR capture will be inverted prior to final playback to counter these factors. Through a process called convolution, the incoming input signal and IR filter are combined to create the final output signal. Pre-recorded guitar takes in several styles will be played through the original amplifier and cabinet, and the same guitar recordings will be played out of the FRFR loudspeaker and IR filter. The two playback methods will both be captured by the non-moving Earthworks TC30k to provide a consistent input source for each comparison.

Research Methodology

To ensure valid results each IR file will be created in the same environment and position of the equipment it will be compared to. The static environments and strictness of placement will reduce any possible external interference with the recorded signals, allowing for no justification in tonal difference. My methods of ensuring unbiased results will be verified by my mentor Seth Shafer prior to the start of the capturing process. The sample collection and IR capturing process will additionally take place in Studio 381 at the Strauss Performing Arts Center, whenever possible, with direct observation from the studio manager in charge, allowing for additional perspective on the sonic neutrality of the tests being prepared and tested.

Timeline

- May 20th, 2022 – Reservations for Studio 381 at Strauss will be made and confirmed by the Music Technology director Seth Shafer.
- May 30th, 2022 – All materials necessary for research completion will be purchased and organized.
- June 14th, 2022 – DI (Direct Input) guitar recordings will be gathered to eliminate dynamic and performance differences present in a live comparison.
- June 21st, 2022 – Guitar amplifier and cabinet combination IR recordings will be captured for later comparisons.
- July 3rd, 2022 – In the same space as the IR captures were gathered, the original amplifiers and cabinets as well as the flat-response loudspeaker will be placed in the same position down to the inch and comparison recordings will be gathered with the measurement microphone used to capture IR recordings.
- July 30th, 2022 – The final samples will be organized and analyzed through a null auditory test, AB comparisons, and spectrogram snapshots at transient points.

- September 15th, 2022 – Final analyses over the measured data will have concluded and a presentation surrounding the findings will be assembled as well as a summary of the complete findings available as a PDF.

Product of Research

The research conducted will produce detailed spectrogram snapshots of transient responses, results of a null test, comparable audio files, and a detailed summary of the findings available as a PDF. Additionally, this research will provide the wider music production community with non-biased results as to the comparability of digital modeling when side by side with the exact amplifier it's copying in the context of differing methods of IR convolution.

Contribution to the Field

There's a long-lived skepticism over the efficacy of physically modeled instruments and equipment when compared to their classic analog counterparts within the wide community of musical performers and technologists. With this research, I hope to gain unbiased results in the ability of these relatively budget-friendly alternatives as well as nearly free alternatives. If the results show minimal auditory difference between compared recordings then the results of this research could potentially save audio professionals thousands of dollars in equipment costs over an extended period, all while delivering world-renown sonic characteristics from thousands of recordings over the last 60+ years. To date, there have been very few unbiased public demonstrations regarding the efficacy of this technology, with most demonstrations acting as a sales pitch rather than neutrally proving the ability of the technology demonstrated.

Roles of the participants

The mentor will provide critiques and observations of the research conducted to validate the results produced by the experiment. Additionally, the mentor will answer any logistical questions regarding the completion of the auditory data recorded throughout the process. The student will gather and organize materials for the experiment, complete the IR and instrument captures, run collected samples through measurement programs, analyze collected data, and create a summary of the findings generated during the analyses.

Previous Internal Funding

There has been no previous internal funding from FUSE or UCRCA granted to the student named above.

Budget

$2,000 - Stipend

The stipend will be allocated as a wage for the student for an estimated 80 hours that will be used to contribute to this project.

$500 - Bugera V55 Infinium 1x12" 55-watt Tube Combo Amp

The Bugera V55 Infinium Combo Amp will be used as one of the amplifier and cabinet combinations being compared.

Citations

Y. Nakahara, Y. Iiyama, Y. Ikeda, and Y. Kaneda, "Shortest Impulse Response Measurement Signal That Realizes Constant Normalized Noise Power in All Frequency Bands," J. Audio Eng. Soc., vol. 70, no. 1/2, pp. 24-35, (2022 January.). DOI: https://doi.org/10.17743/jaes.2021.0048

A. Farina, "Advancements in Impulse Response Measurements by Sine Sweeps," presented at the 122nd Convention of the Audio Engineering Society (2007 May), paper 7121.

A Sonically Neutral Comparison Between Guitar Amplifiers and Digital Mimicry Letter of Mentor Support

Student: Sage Rice

Faculty Mentor: Dr. Seth Shafer

An analysis of viability of the project objectives and methodology

In the last decade, the music industry has seen a growing interest in guitar amplifier modeling. This has found a particular foothold for live performers who are attracted to the possibility of trading multiple heavy guitar amps for a single, all-in-one solution. Sage Rice proposes to compare the accuracy of a modelled guitar amp to the original equipment. The comparison includes a commercial product that is representative of the all-in-one solution. He will also build his own digital emulation using free/cheap software. He will analyze the recordings of the original amp, the commercial amp modeler, and his DIY amp modeler to see how accurately the models capture the frequency range, tonal characteristics, dynamic response, and a variety of other metrics. In his proposal, he accurately describes the underlying concepts for amp modeling: impulse responses and linear convolution. Pre-made code and widely available software mean that his DIY modeler is attainable. The outcome from this study will provide an interesting look at the state-of-the-art in commercial amp modeling compared to the inexpensive options available to intrepid DIYers. This could, perhaps, eventually lead Mr. Rice in the direction of developing his own commercial product, at some point in the future, should he discover ways to either improve the accuracy of the modeling, reduce the product cost, or both.

Verification of proposed budget needs and costs

I have reviewed the budget for this proposal and I can verify that the requested amp modeler and flat-frequency speaker (amp) appropriate for this research project. The costs associated with each item are accurate.

Description of the mentor support to be provided

My role in this project will be to provide supervision over Mr. Rice's research in IR gathering and convolution processing. I will also help him analyze his resulting data.

Description of the student's background and preparation for the project

Mr. Rice has been a student in the Bachelor of Art in Music with a concentration in Music Technology since Fall 2019. In approaching me about this project and preparing the proposal, I believe his research and imagination reflect a readiness to undertake this study.