DDSP Guitar Amp: Interpretable Guitar Amplifier Modeling

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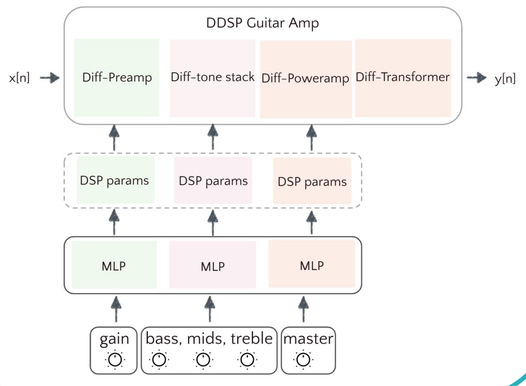
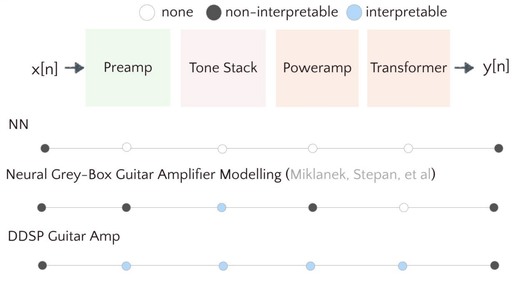
Overview

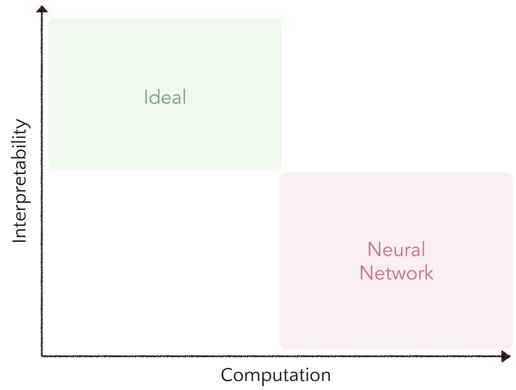
We propose a low-computation cost & interpretable guitar amplifier model



Motivation & Comparison



Miklanek, Stepan, et al. "Neural grey-box guitar amplifier modelling with limited data." *International Conference on Digital Audio Effects*. Aalborg University, 2023.

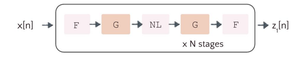


Proposed Model

Preamp

Purpose: Determine primary tone of the amp

- Wiener HammerStein with multiple stages



- In-series
  - F Filter : Determines the amount of distortion per frequency
  - G Pre-Gain : Determines the level of the distortion
  - NL Nonlinear : Introduce the nonlinearity
  - G Post-Gain : Adjust output level without altering distortion characteristics
  - F Filter : Alter the frequency after nonlinear function
- TanH v.s. GRU with hidden size 1

TanH	Ours
Static	Dynamic
Symmetric	Asymmetric
Non-Learnable	Learnable

Tone Stack

- Low-shelf + peak + high-shelf filter

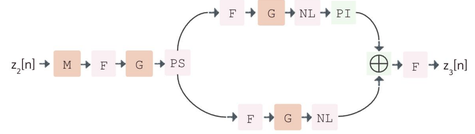
  - L : Control "bass" frequency responses (low)
  - P : Control "mids" frequency responses (mid)
  - H : Control "treble" frequency responses (high)

Purpose: Alter the frequency response

Power Amp

Purpose: Tone EnhanceMent

- Phase Splitter (nonlinear) + Phase Inversion
- Wiener HammerStein with single stage
- Master Volume + Filter (emulate feedback)

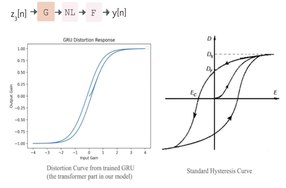


- PS Phase Splitter : Split into two identical signal that are 180 degrees out of phase with each other
- PI Phase Inv. : Inverse phase back
- M Master : Increase level

Transformer

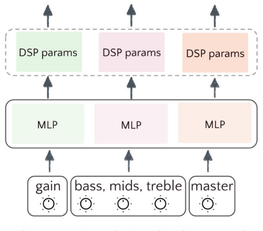
Purpose: Dynamics Control & coloring

- Hysteresis behavior by GRU with hidden size 1



Knob Controller

Purpose: The mapping relationship between knob and dsp parameters is nonlinear



Core idea: The mapping relationship between knob and dsp parameters is nonlinear

Recap

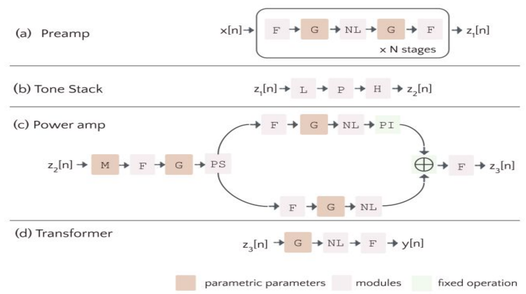


Fig. 2. Details of DDSP Guitar Amp. Letters in the squares denote their respective types—F: filter, G: gain, NL: nonlinear function, L: low-shelf filter, P: peak filter, H: high-shelf filter, M: master, PS: phase splitter, PI: phase inversion. Orange blocks: knob controller-estimated parameters for multiplication. Pink blocks: designed operations with Knob Controller-predicted parameters. Green blocks: fixed operations without learnable parameters. Best viewed in color.

Results

Model	Seen knob conditions		Unseen knob conditions		Ops/sample	Params
	MAE ↓	MR-STFT ↓	MAE ↓	MR-STFT ↓		
A. Small Concat-GRU-8	0.057	4.302	0.075	5.762	1,344	369
B. Big Concat-GRU-48	0.013	1.214	0.023	1.851	19,872	7,969
C. WH Only	0.317	2.552	0.189	4.675	736	4,462
D. WH+LPH+WH	0.063	5.098	0.066	5.803	995	10,213
E. WH+LPH+POW	0.034	2.979	0.057	4.825	1,243	8,200
F. WH+LPH+POW+TRANS	0.024	2.161	0.043	3.972	1,352	10,126

Table 1. Evaluation results of (*A*–*B*) black-box baselines and (*F*) the proposed DDSP model and (*C*–*E*) its ablations.

Conclusion & Future work

- Low-computation cost & interpretable model
- Future work:
  - Advanced design to other topologies
  - Dynamic model architectures for clean/crunch/high-gain guitar amp
  - Oversampling module

paper: https://arxiv.org/abs/2408.11405
demo: https://ytsrt66589.github.io/ddspGuitarAmp_Demo/

Demo:

Paper