Deep Learning for Tube Amplifier Emulation

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1 Introduction

- Analog audio effects and synthesizers often owe their sound to circuit nonlinearities.
- Previously, white-box methods have been needed for creating faithful models of nonlinear analog circuits.
- Conventional black-box modeling methods typically lead to less accurate models and do not capture behavior of user controls.
- This work: black-box modeling of controllable nonlinear audio circuits using a deep neural network.
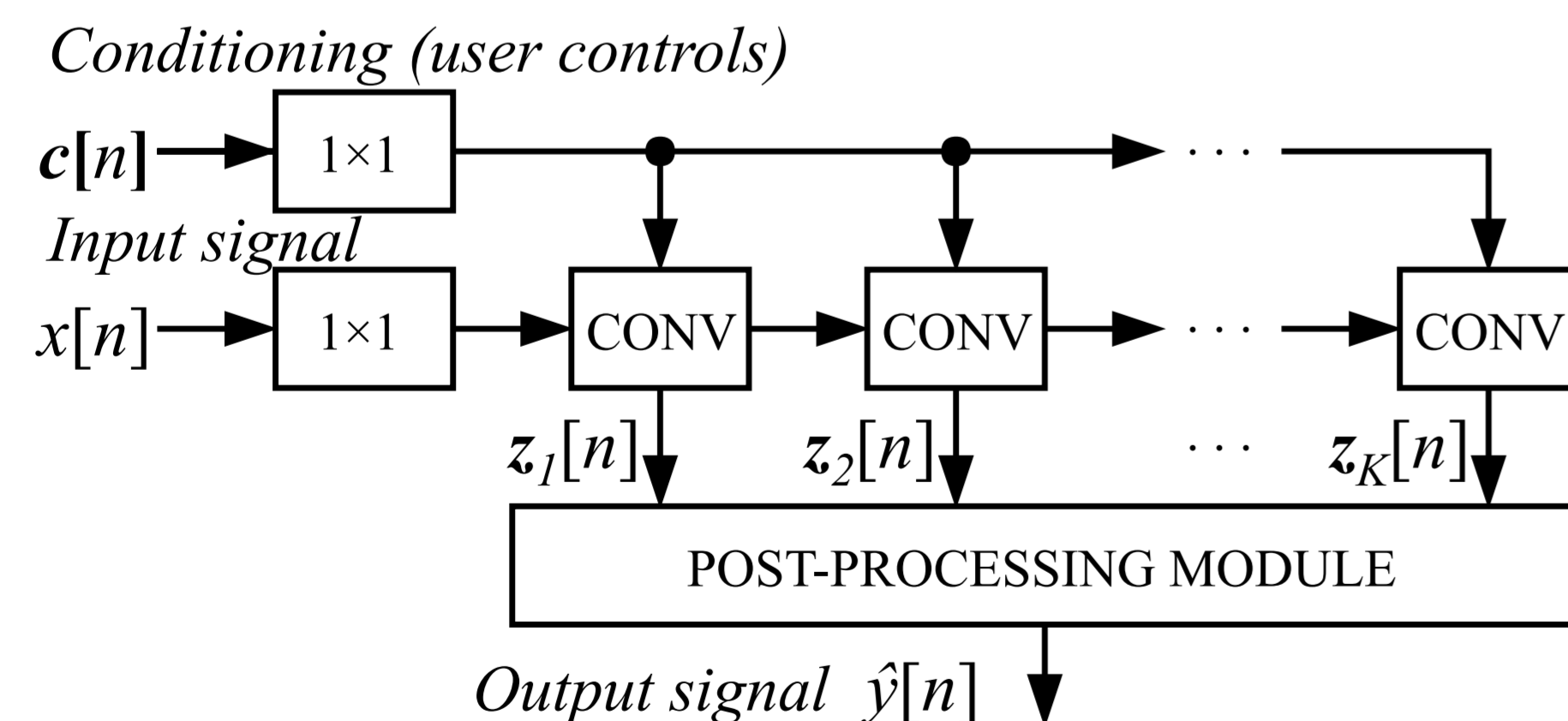
2 Proposed Deep Neural Network

Fig 1. Model architecture.

- Feedforward variant of the WaveNet CNN [1].
- Training data is collected by processing audio through the circuit and measuring the output.
  - This work: Fender Bassman 56F-A vacuum-tube preamplifier (a detailed SPICE model).
  - Model is conditioned with position of the gain knob.
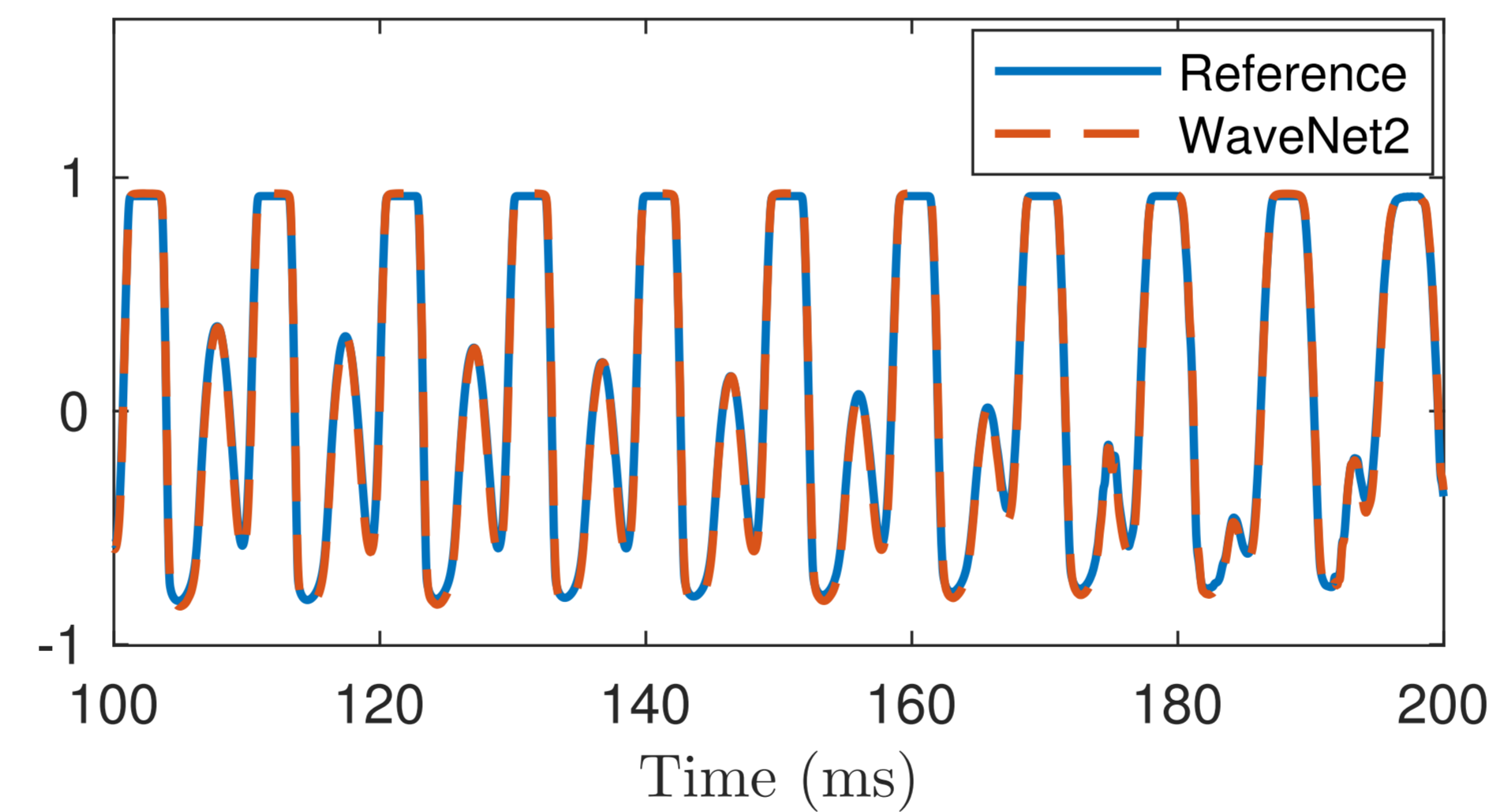
3 Results

Fig 2. Waveform comparison: Ref. vs. WaveNet2.

- Method was compared with a state-of-the-art black-box model (Block) [2] and a multilayer perceptron (MLP).
- Objective evaluation: proposed method has lowest error-to-signal ratio, with an average error of 2.0% on the test data with a high-gain amplifier setting.

- MUSHRA listening test with 10 subjects (+4 excluded) with a SPICE model as a Reference: The proposed methods WaveNet1 and WaveNet2 were preferred.
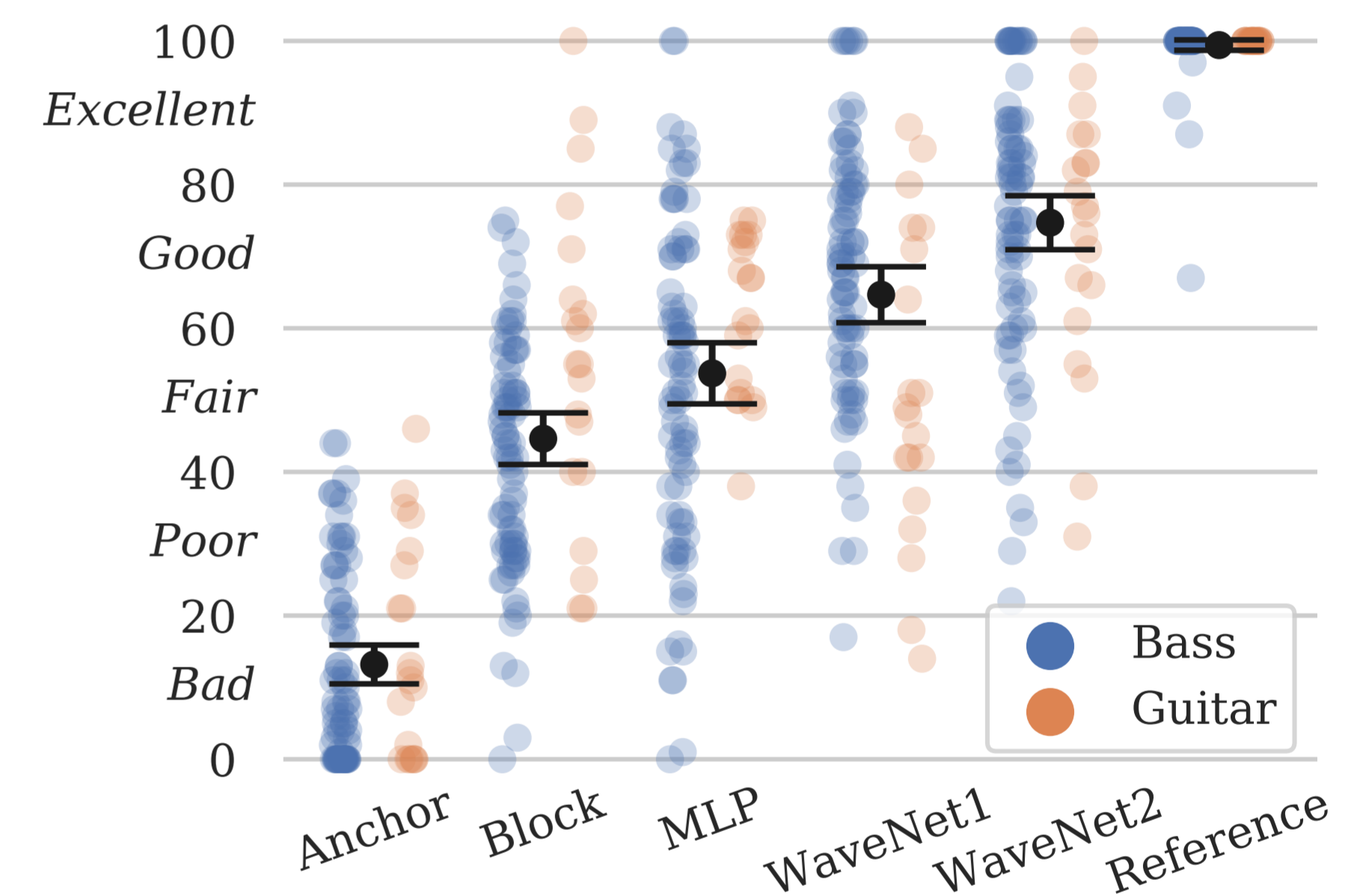

Fig 3. Results of MUSHRA listening test.

- Audio examples: `http://research.spa.aalto.fi/publications/papers/icassp19-deep/`

References

[1] A. van den Oord *et al.*, "WaveNet: A generative model for raw audio," *ArXiv pre-print*, 2016. arXiv:1609.03499 [cs.SD].

[2] F. Eichas and U. Zölzer, "Black-box modeling of distortion circuits with block-oriented models," in *Proc. Int. Conf. Digital Audio Effects (DAFx)*, (Brno, Czech Republic), pp. 39–45, Sept. 2016.