Emulating LA-2A Optical Compressor

With a Feed-Forward Digital Compressor Using the Newton-Raphson Method

@DMRN+19

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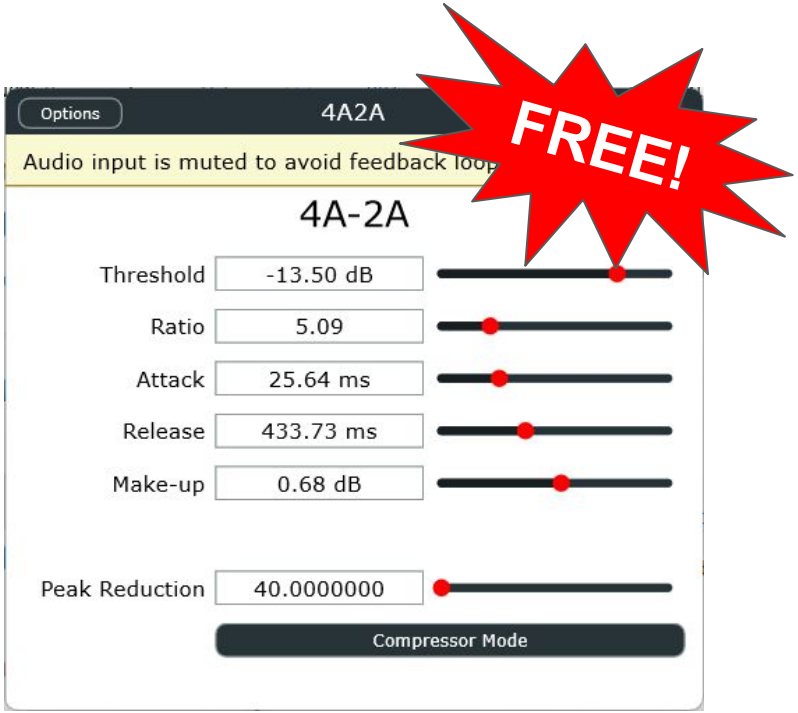
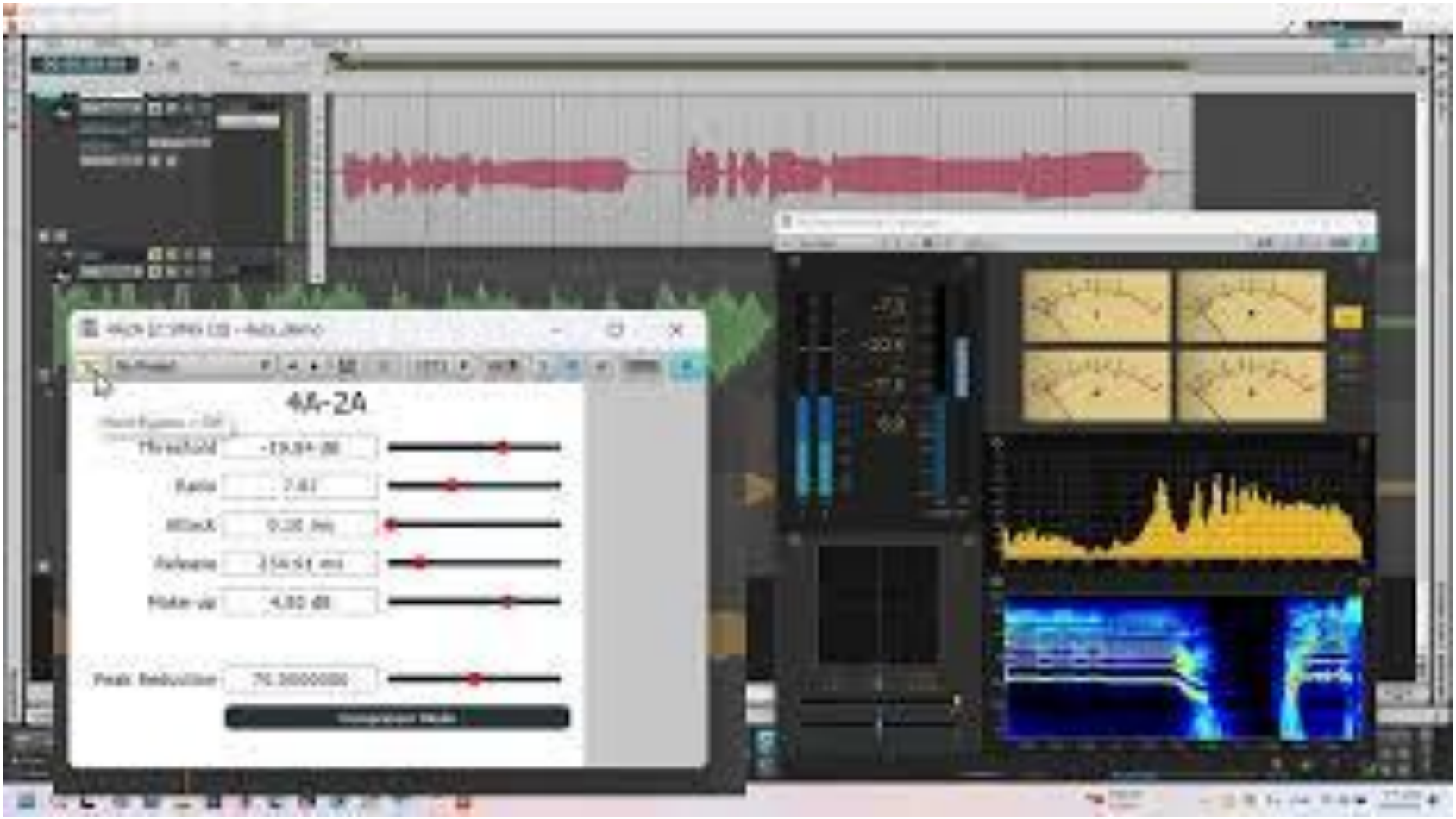
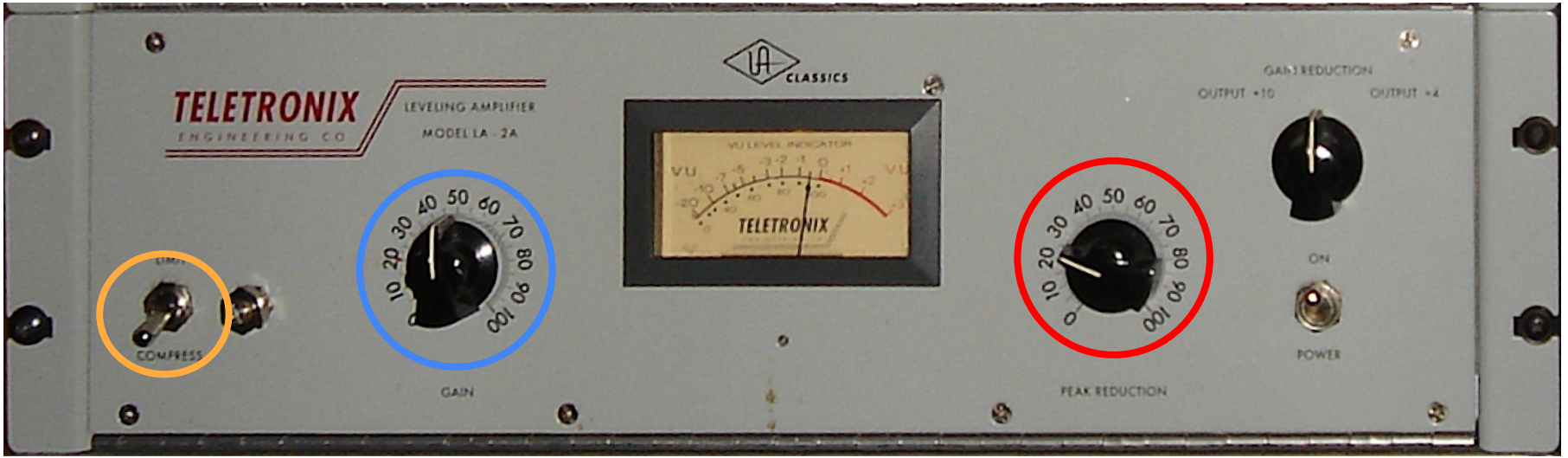
Our contribution: 4A-2A

- A **free** compressor plugin
  - https://github.com/aim-qmul/4a2a
- It emulates LA-2A
- Interpretable parameters
- "4" stands for
  - ~~C4DM~~
  - Feed-4ward

Download




44-24



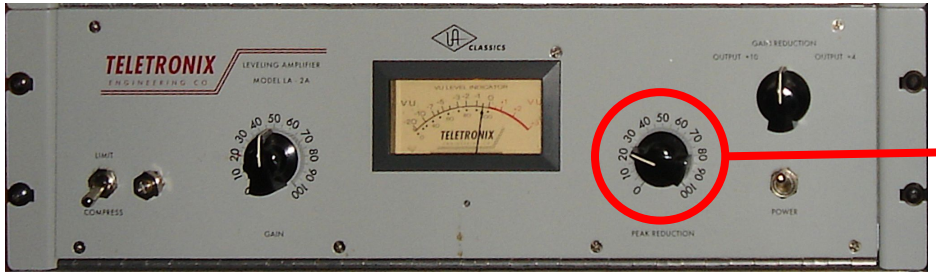
Limiter/Compressor mode switch

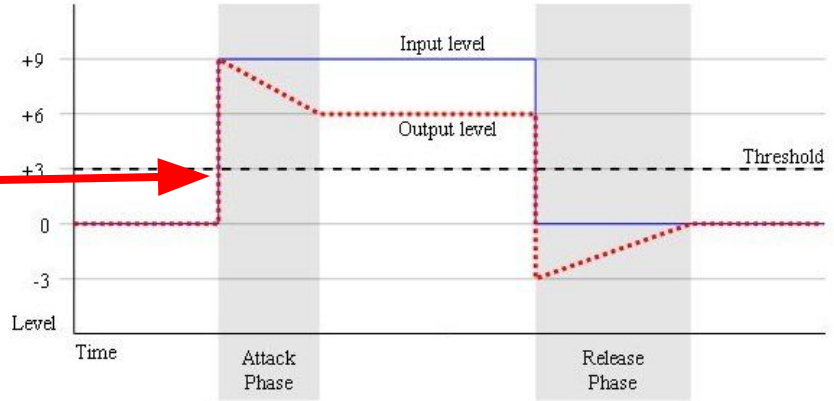
Gain reduction

Output gain

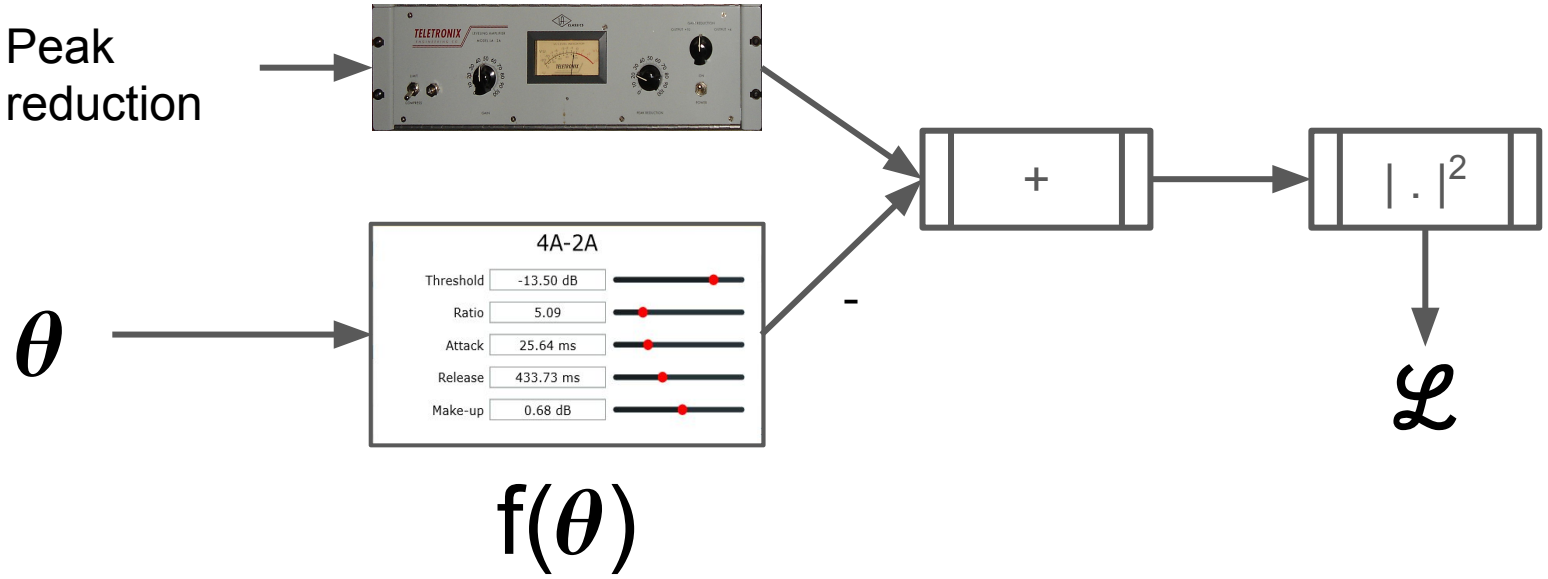
Target task

- A mapping between LA-2A and common compressor descriptor
  - ~~Virtual analog modelling~~
  - Sound matching

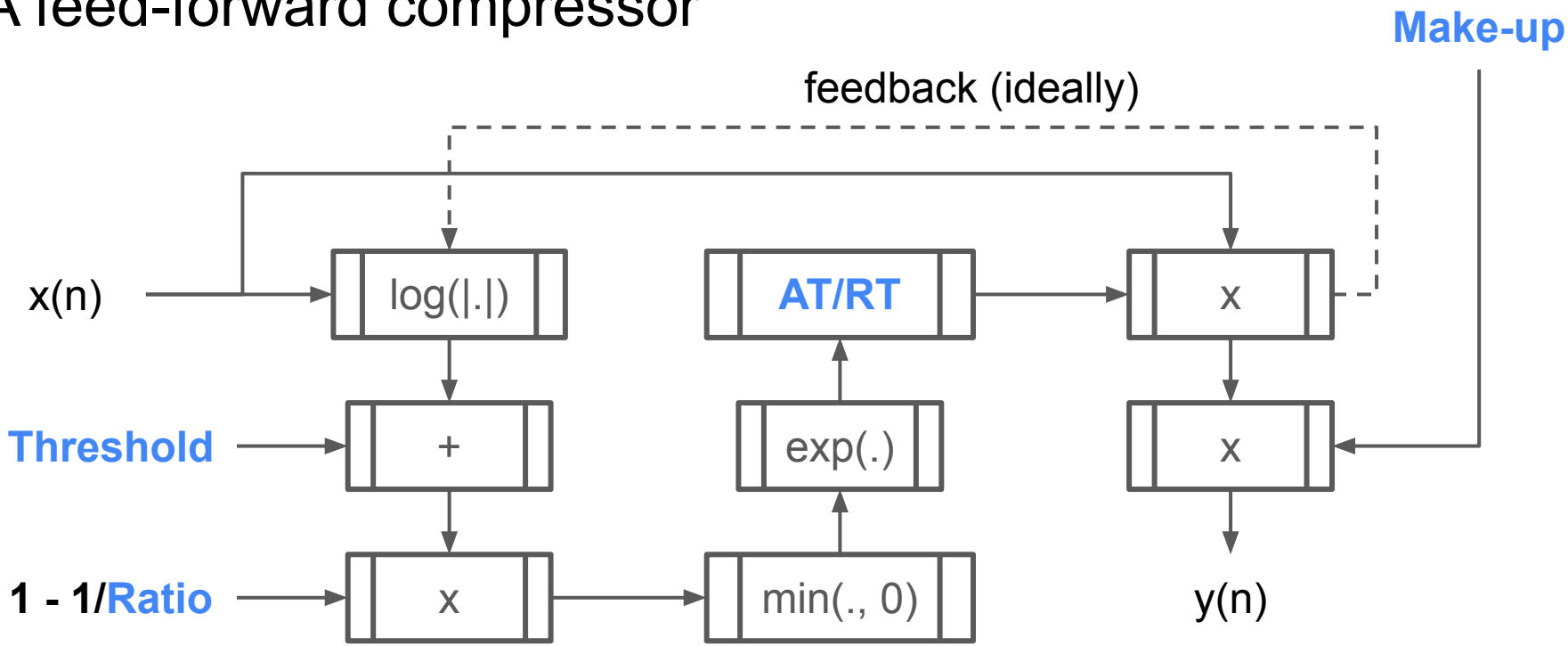




Problem formulation



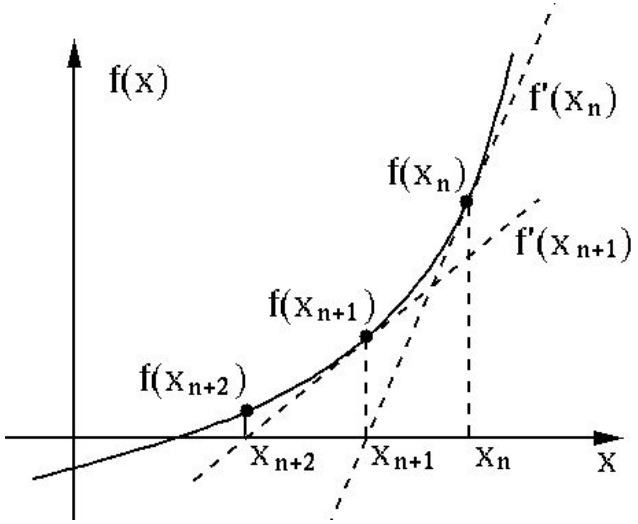
A feed-forward compressor



The Newton-Raphson optimisation

$$\theta \leftarrow \theta - [\nabla^2 \mathcal{L}(\theta)]^{-1} \nabla \mathcal{L}(\theta)$$

$$\nabla^2 \mathcal{L}(\theta) \in \mathbb{R}^{5 \times 5}$$



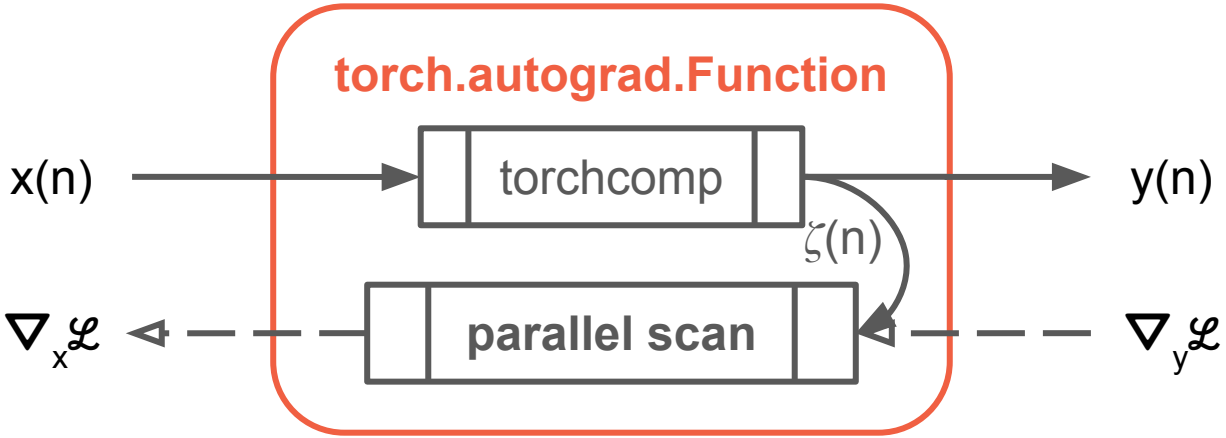
Assuming the criterion is convex. (looks like it is, empirically 😅)

Differentiable attack/release

AT/RT

decision flag of attack/release phase

$$\beta(n) = \alpha_{\text{at}}^{\zeta(n)} \alpha_{\text{rt}}^{1-\zeta(n)}$$
$$\hat{g}(n) = \beta(n) g(n) + (1 - \beta(n)) \hat{g}(n-1)$$



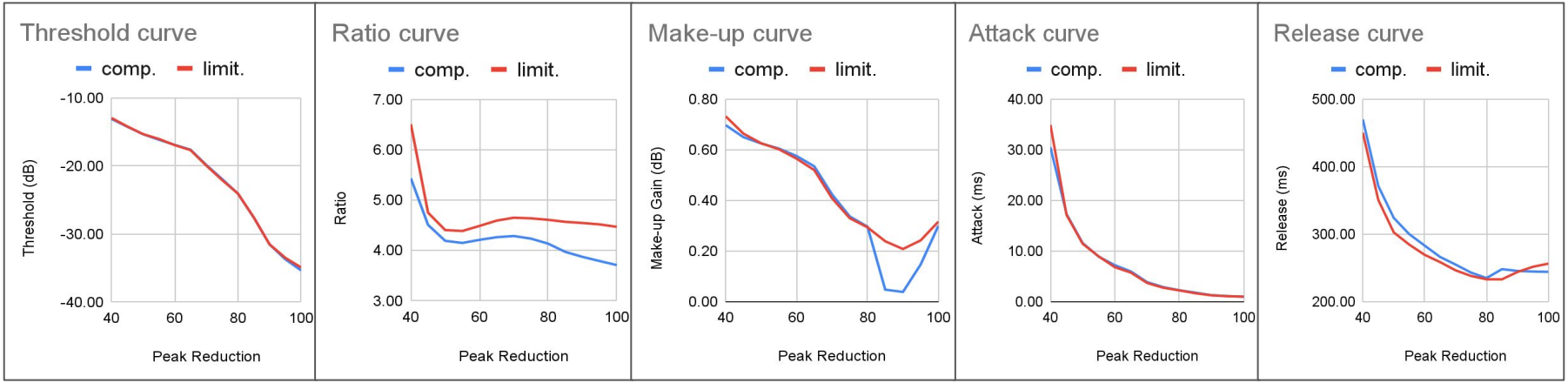
Yu, C. Y., Mitcheltree, C., Carson, A., Bilbao, S., Reiss, J. D., & Fazekas, G. (2024). Differentiable All-pole Filters for Time-varying Audio Systems. DAFx 2024.

Training details

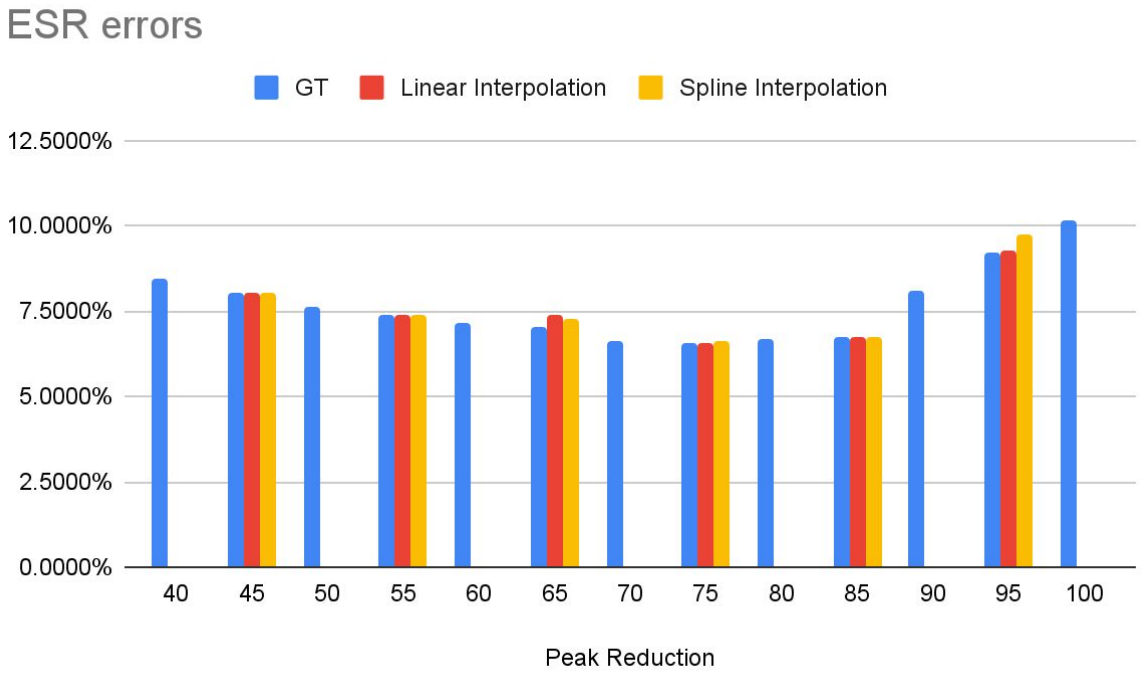
- SignalTrain dataset
  - peak reduction ∈ [0, 5, 10,..., 100]
  - 20 minutes for each
  - limiter/compressor mode
- Fast training on GPU with `torchcomp`
- slices into 12 seconds chunks
- parallel associative scan for backpropagation
- ~= 3 seconds per step on RTX 3060
- Rounly 10 steps per setting
  - finish training in 30 seconds

- Initial values
  - threshold: -36 dB
  - ratio: 4
  - attack: 1 ms
  - release: 200 ms
- Use results from peak reduction + 5 to initialise the parameters
- Stop at peak reduction = 40 due to **negative curvature** of the loss surface

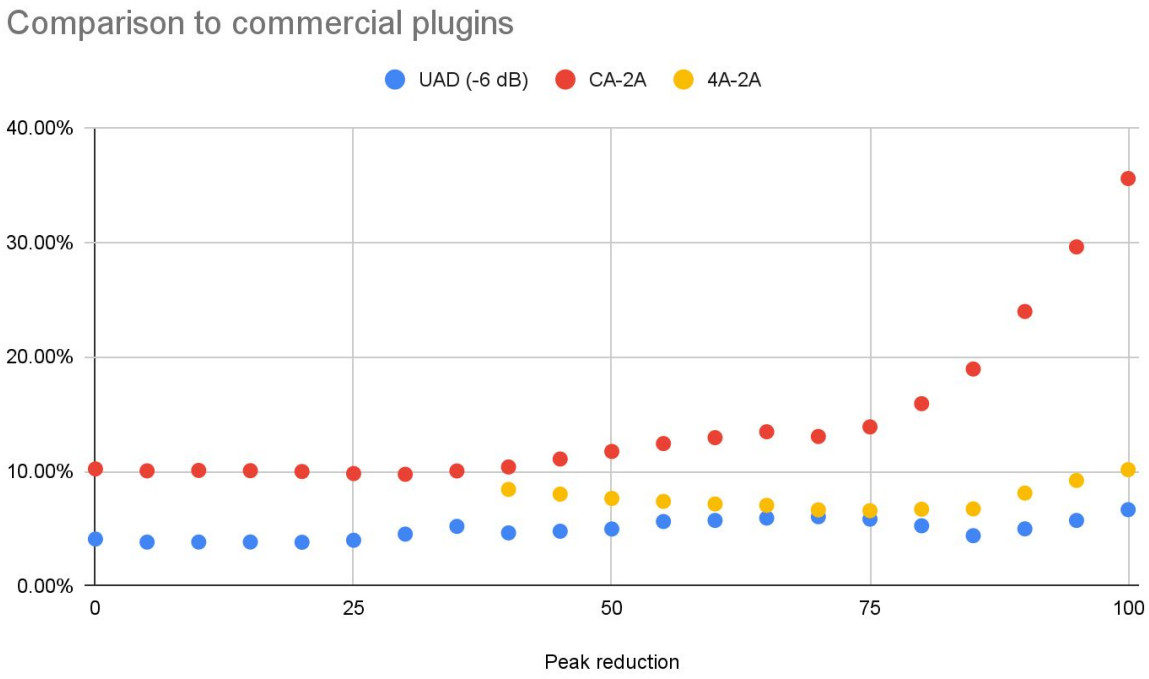
Results


Threshold curve
comp.
limit.
-10.00
-20.00
-30.00
-40.00
Threshold (dB)
40
60
80
100
Peak Reduction
Ratio curve
comp.
limit.
7.00
6.00
5.00
4.00
3.00
Ratio
40
60
80
100
Peak Reduction
Make-up curve
comp.
limit.
0.80
0.60
0.40
0.20
0.00
Make-up Gain (dB)
40
60
80
100
Peak Reduction
Attack curve
comp.
limit.
40.00
30.00
20.00
10.00
0.00
Attack (ms)
40
60
80
100
Peak Reduction
Release curve
comp.
limit.
500.00
400.00
300.00
200.00
Release (ms)
40
60
80
100
Peak Reduction

Interpolation errors



Comparison regarding Error-to-Signal Ratio (ESR)



Future plans

- Frequency-dependent metrics like LSD
- Compare to other neural effects emulators
- Try Newton’s method for emulating other audio effects, or more complex signal chain