WeightWatcher:
A Diagnostic Tool for Deep Neural Networks

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pip install weightwatcher

Open source tool: weightwatcher

https://github.com/CalculatedContent/WeightWatcher

WeightWatcher (WW): is an open-source, diagnostic tool for analyzing Deep Neural Networks (DNN), without needing access to training or even test data. It can be used to:

- analyze pre/trained pyTorch and keras models
- inspect models that are difficult to train
- gauge improvements in model performance
- predict test accuracies across different models
- detect potential problems when compressing or fine-tuning pretrained models

It is based on theoretical research (done injoint with UC Berkeley) into *Why Deep Learning Works*, using ideas from Random Matrix Theory (RMT), Statistical Mechanics, and Strongly Correlated Systems.

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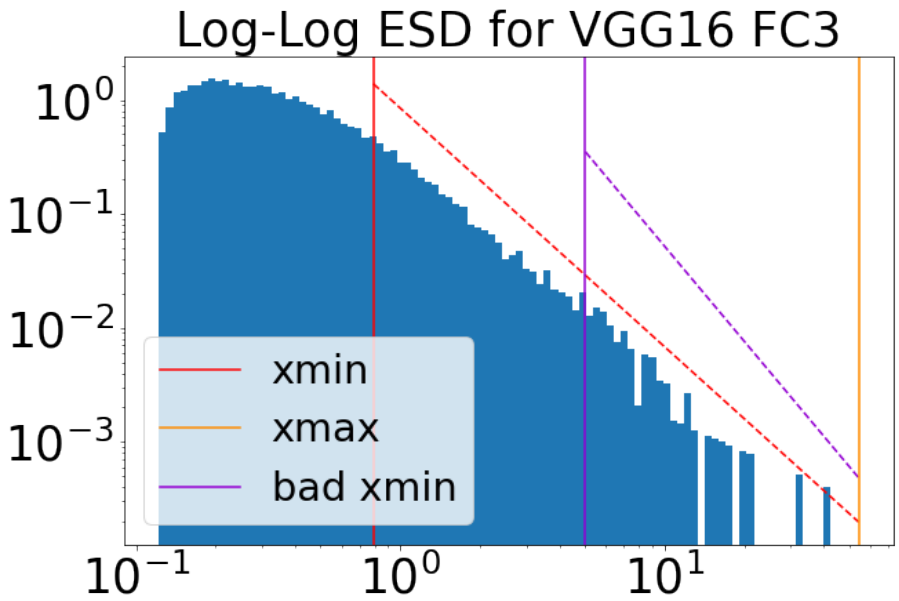
Shape and Scale Metrics

WeightWatcher (WW): analyzes the shape and scale of the correlations in the layer weight matrices:



WW: extracts, plots, and fits the Empirical Spectral Density (ESD, or eigenvalues) for each layer weight matrix (or tensor slice).

The *tail of the ESD* contains the most informative components.

The shape of the tail carries useful information!

WeightWatcher: Usage

Usage

```
import weightwatcher as ww
watcher = ww.WeightWatcher(model=model)
details = watcher.analyze(plot=True)
summary = watcher.get_summary(details)
```

	layer_id	name	D	M	N	alpha	alpha_weighted	has_esd	lambda_max	layer_type	...	rand_num_spikes	rand_sigma_mp	ra
0	2	None	0.240111	3.0	64.0	2.400712	2.627967	1.0	12.435451	LAYER_TYPE.CONV2D	...	135.0	1.000000	
1	5	None	0.112669	64.0	128.0	7.116304	4.721276	1.0	4.607285	LAYER_TYPE.CONV2D	...	25.0	0.551250	
2	8	None	0.076209	128.0	256.0	2.981087	1.739893	1.0	3.833927	LAYER_TYPE.CONV2D	...	17.0	0.451562	
3	10	None	0.068890	256.0	256.0	5.667264	2.600458	1.0	2.876445	LAYER_TYPE.CONV2D	...	0.0	0.935068	
4	13	None	0.084938	256.0	512.0	2.593428	1.432684	1.0	3.568032	LAYER_TYPE.CONV2D	...	8.0	0.431523	
5	15	None	0.038416	512.0	512.0	3.309962	2.216486	1.0	4.673487	LAYER_TYPE.CONV2D	...	0.0	0.939111	
6	18	None	0.052924	512.0	512.0	3.446656	1.859810	1.0	3.464163	LAYER_TYPE.CONV2D	...	0.0	0.888574	
7	20	None	0.034290	512.0	512.0	3.261262	2.524426	1.0	5.943799	LAYER_TYPE.CONV2D	...	0.0	0.942012	
8	25	None	0.032563	4096.0	25088.0	2.325065	3.583809	1.0	34.784030	LAYER_TYPE.DENSE	...	1.0	0.898506	
9	28	None	0.030891	4096.0	4096.0	2.167513	3.858526	1.0	60.278519	LAYER_TYPE.DENSE	...	1.0	0.959863	
10	31	None	0.039773	1000.0	4096.0	2.825653	4.999373	1.0	58.786867	LAYER_TYPE.DENSE	...	206.0	1.000000	

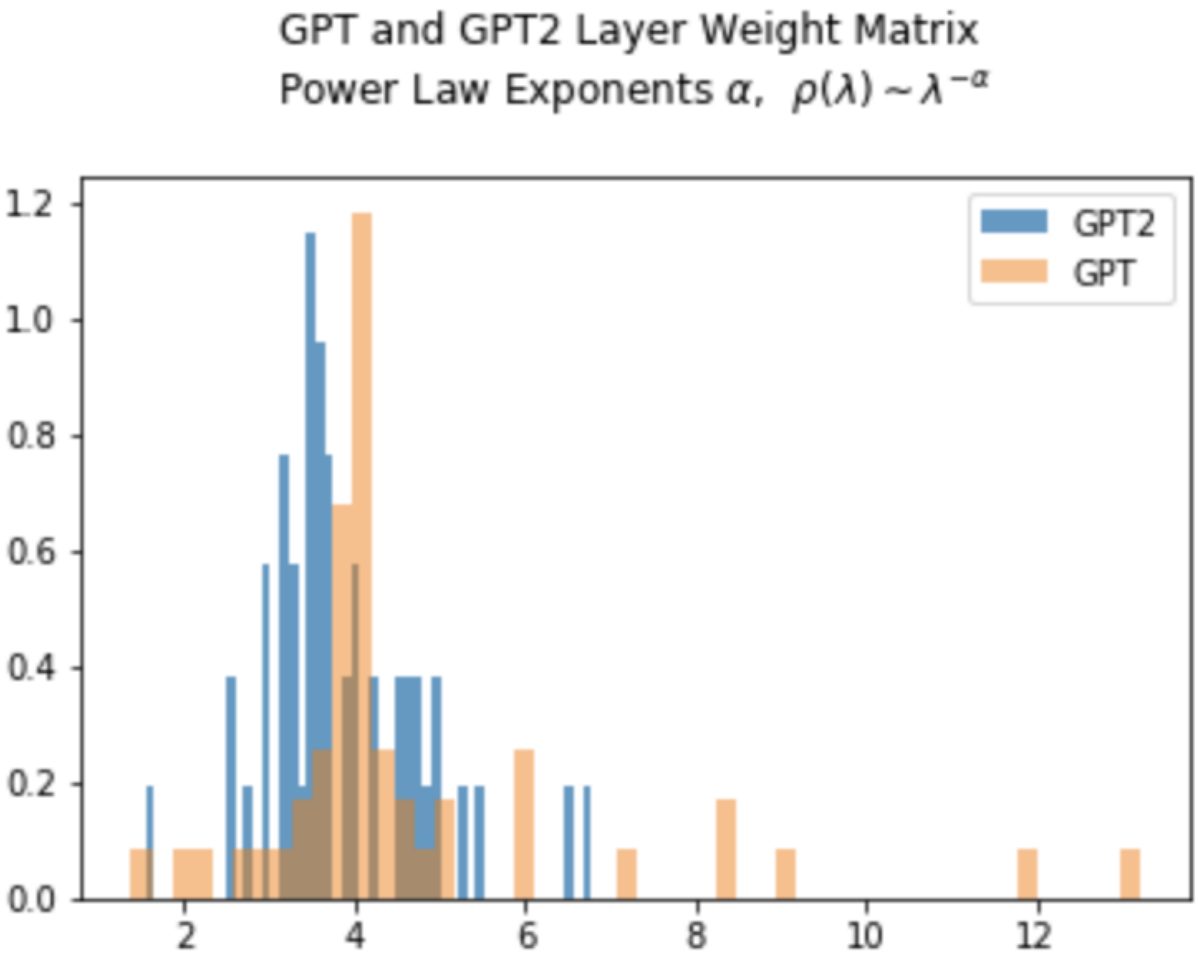
```
summary = watcher.get_summary(details)
```

```
{'log_norm': 2.11,
  'alpha': 3.06,
  'alpha_weighted': 2.78,
  'log_alpha_norm': 3.21,
  'log_spectral_norm': 0.89,
  'stable_rank': 20.90,
  'mp_softrank': 0.52}]
```

Layer-by-Layer Analysis

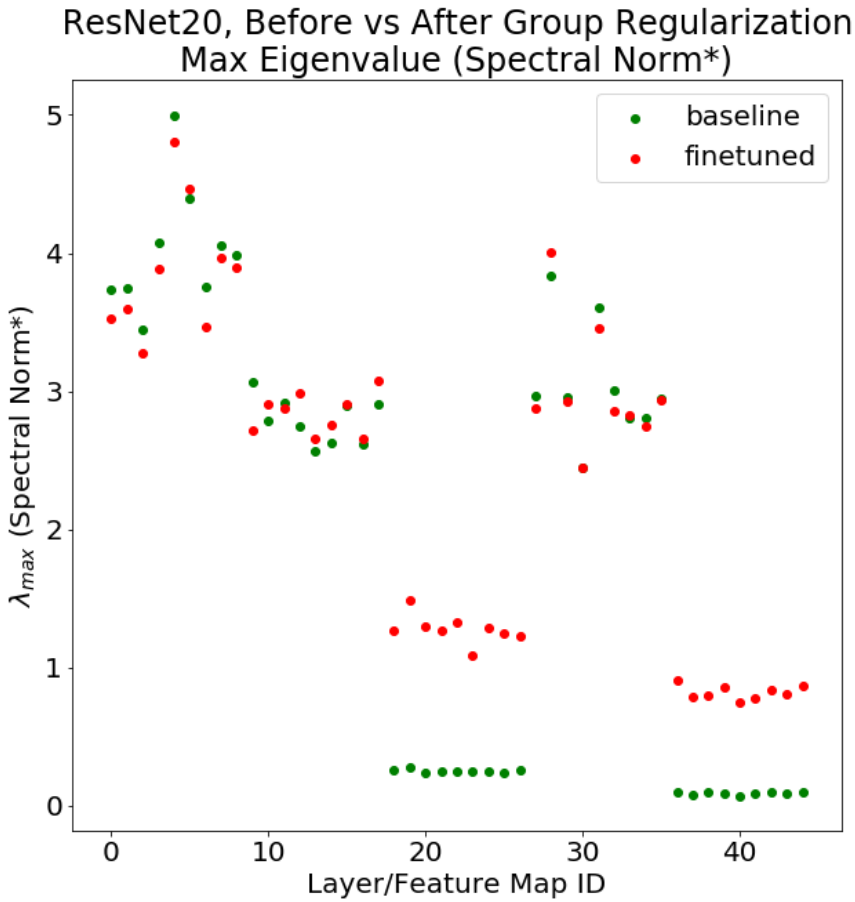
WW layer metrics: can detect potential problems *in the ESD shapes*

Poorly trained models (orange) can have unusually large layer α's.



Layer-by-Layer Analysis

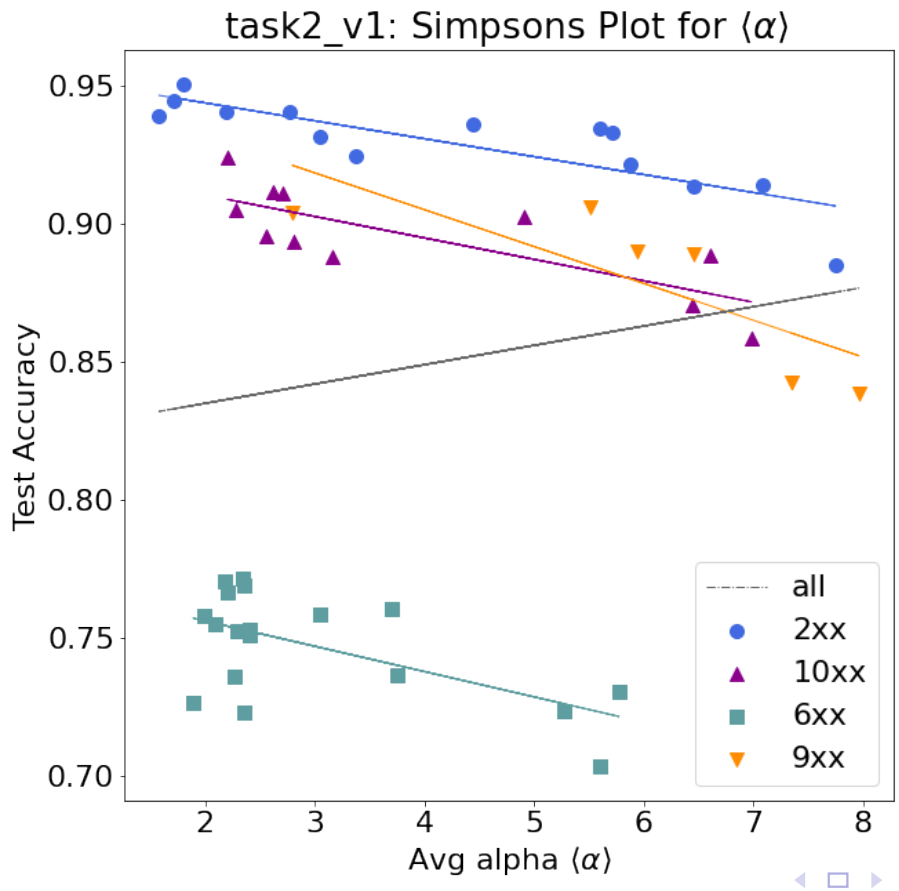
WW layer metrics: can detect potential problems *in the ESD Scales*
Compressed models (red) can show unexpected scale changes



example from Intel distiller Group Regularization technique

α: a regularization metric

The WW $\langle\alpha\rangle$ metric: predicts test accuracy for a given model (i.e same depth) when varying the regularization hyper-parameters (such as batch size, weight decay, momentum, etc.)—*without access to the test or training data.*



$\hat{\alpha}$: a multi-purpose metric

The WW $\hat{\alpha}$ metric: predicts test accuracy for models in the same architecture series across varying depth and other architecture parameters and regularization hyper-parameters—-*without access to the test or training data.*