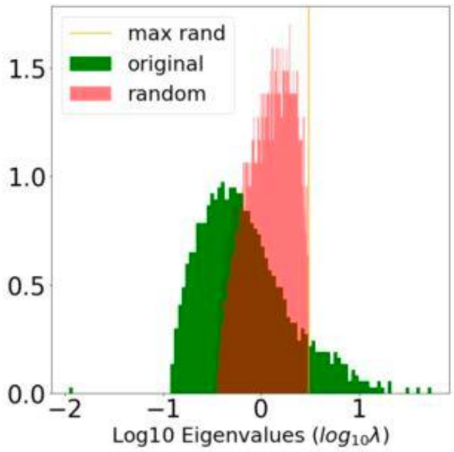
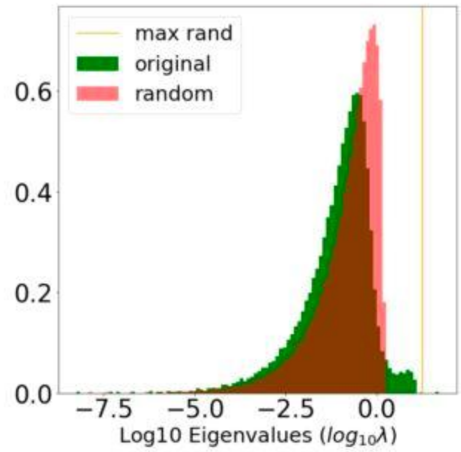
how-determine-machine-learning-model-overtrained?

By Charles Martin, Calculation Consulting



(a) ESD of $\mathbf{W}$ and randomized $\mathbf{W}$.



(b) ESD of $\mathbf{W}$ and randomized $\mathbf{W}$.

Are your models over-trained? The weightwatcher tool can detect the signatures of overtraining in specific layers of a pre/trained Deep Neural Networks.

In the Figure above, fig (a) is well trained, whereas fig (b) may be over-trained. That orange spike on the far right is the tell-tale clue; it's what we call a *Correlation Trap.* Weightwatcher can detect the signatures of overtraining in specific layers of a pre/trained Deep Neural Networks. In this post, we show how to use the weightwatcher tool to do this.

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 analyzes the weight matrices of a pre/trained DNN, layer-by-layer, to help you detect potential problems. Problems that can not be seen by just looking at the test accuracy or the training loss.

Installation:

```
pip install weightwatcher
```

Usage:

```
import weightwatcher as ww
import torchvision.models as models
```

```
model = models.vgg19_bn(pretrained=True)
watcher = ww.WeightWatcher(model=model)
details = watcher.analyze(plot=True, randomize=True)
```

For each layer, Weightwatcher plots the Empirical Spectral Density, or ESD. This is just a histogram of the eigenvalues of the layer correlation matrix **X=W^{T}W**.

```
import numpy as np
import matplotlib,pyplot as plt
...
X = np.dot(W,W.T)
evals, evecs = np.linalg.eig(X(
plt.hist(evals, bin=100, density=True)
...
```

By specifying the randomize option, WW randomizes elements of the weight matrix **W**, and then computes the it's ESD. This randomized ESD is overlaid on the orginal ESD of **X**, and ploted on a log scale.
This is shown above. The original layer ESD is **green**; the randomized ESD is **red**, And the **orange line** depicts the largest eigenvalue λmax of the randomized ESD.
If the layer is well trained matrix, then when **W** is randomized, it's ESD will look like that of a normally distributed random matrix. This is shown in Figure (a), above.
But if the layer is over-trained, then it's weight matrix **W** may have some unusually large elements, where the correlations may concentrated, or become *trapped*. In this case, the ESD may have 1 or more unusually large eigenvalues. This is shown in Figure (b) above, with the **orange line** extending to the far right of the bulk of the **red** ESD.
Notice also that in Figure (a), the **green** ESD is very Heavy Tailed, with the histogram extending out to log10=2, or a largest eigenvalue of nearly 100: $\lambda \sim 10^2$. But in Figure (b),, the green ESD has a distinctly different shape and is smaller in scale than in Figure (a). In fact, in (b), the **green** (original) and **red** (randomized) layer ESDs look almost the same, except for a small shelf of larger **green** eigenvalues, extending out to and concentrating around the **orange line**.
In cases like this, we can identify the orange line as a *Correlation Trap.*
This indicates that something went wrong in training this layer, and the model did not capture the correlations in this layer in a way that will generalize well to other examples.

Conclusion

Using the Weight Watcher tool, you can detect this and other potential problems when training or fine-tuning your Deep Neural Networks.
You can learn more about it on the [WeightWatcher github website.]