

Statistical Complexity Reveals Internal Learning Dynamics Of Deep Neural Networks In Alzheimer's MRI Classification

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INTRODUCTION

How does the statistical complexity of a model change layer by layer, as the input data increases? Does this help to understand better the structure and performance of a neural network model? How does statistical complexity structure compare with accuracy metric?

METHODS

1 Synaptic Weights:

The weights are extracted from the model and initialized using Kaiming.
Histogram = count of synaptic weights in each bin.

Total counts of weight in the model = 6907808.

No of bins = 100 and $lr = 0.00001$

2 Probability distribution

P_i = counts in bin i / total counts of weights

3 Entropy, the measure of uncertainty is obtained by:

$$H = -K \sum_{i=1}^N p_i \log p_i$$

4 Disequilibrium, the measure of deviation uniform distribution:

5 Statistical complexity is obtained by:

$$H = -K \sum_{i=1}^N p_i \log p_i \quad \mathbf{X} D = \sum_i (p_i - 1/N)^2$$

Training:
AD: 10%; 77, 100%; 772
MCI: 10%; 55, 100%; 551

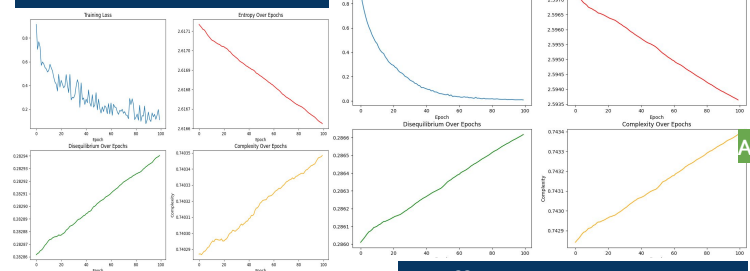
Val:
AD: 10%; 10, 100%; 96
MCI: 10%; 7, 100%; 68

Test:
AD: 10%; 10, 100%; 97
MCI: 10%; 7, 100%; 70

RESULTS

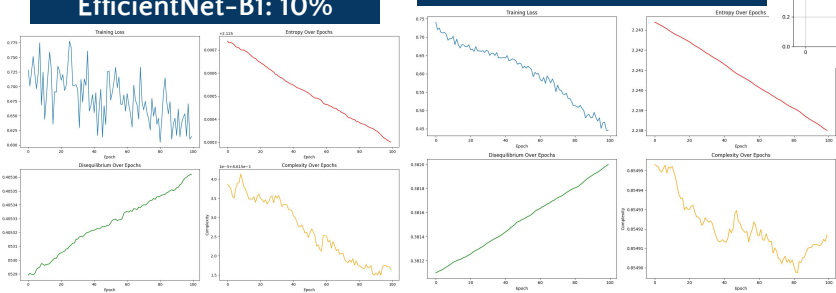
DenseNet-121: 100%

DenseNet-121: 10%

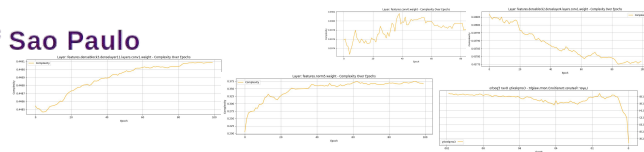


EfficientNet-B1: 10%

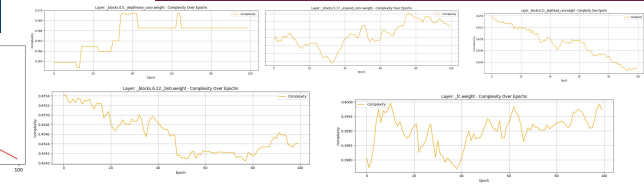
EfficientNet-B1: 100%



DenseNet-121: Layer by Layer: 100%

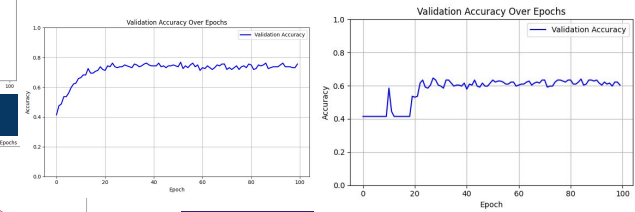


EfficientNet-B1: Layer by Layer: 100%



Accuracy: DenseNet-121: 100%

Accuracy: Efficient Net-B1: 100%



CONCLUSIONS

- This study introduces statistical complexity as a metric to determine the performance of ML models during AD/MCI classification.
- DenseNet-121 is stable, while EfficientNet-B1 is less stable with limited data.
- Statistical complexity improves interpretability in data-constrained settings.

1. S. Li, K. W. et al. Temporal detection in Alzheimer's disease: A review and comparison of methods. *Molecular Neurobiology*, 55, 2, 2021-2032, 2018.
2. Mariani, J. et al. Emerging insights into synaptic dysregulation in Alzheimer's disease. *Current Neurology*, 2022.
3. Huang, G. et al. Deeply connected convolutional networks. *CVPR Proceedings*, 4759-4768, 2017.
4. Tan, M. et al. EfficientNet: Rethinking model scaling for convolutional neural networks. *arXiv preprint, arXiv:1905.11946*, 2019.
5. Omotoso, S. et al. A computational deep learning method for Alzheimer's disease classification using integrated processed networks. *Frontiers in Computational Neuroscience*, 18, 2024.