Can Neural Nets Learn the Same Model Twice? Investigating Reproducibility and Double Descent from the Decision Boundary Perspective

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MOTIVATION

🤔 Do neural nets learn the same model twice?

🤔 Do different neural architectures have measurable differences in inductive bias?

🤔 How are decision regions changing in double descent phenomenon in neural networks?

Drawing decision regions

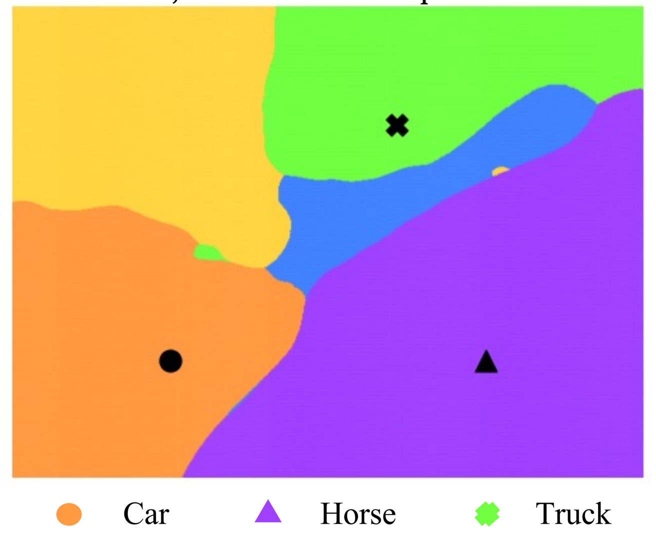
$(x_1, x_2, x_3) \sim \mathcal{D}^3$ Randomly sampled triplet from input space

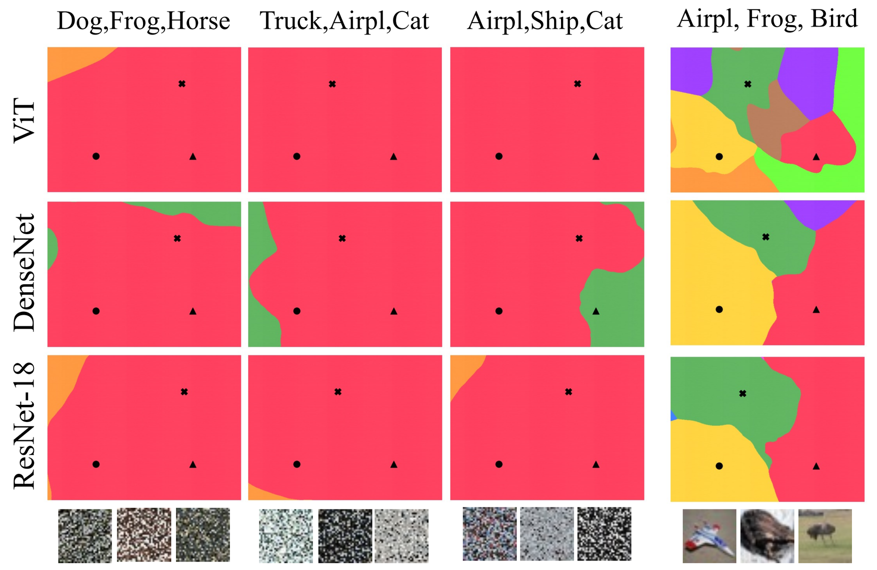
$\vec{v_1} = x_2 - x_1, \vec{v_2} = x_3 - x_1$

$-0.1 \leq \alpha, \beta \leq 1.1$

$$\alpha \cdot \max(\vec{v_1} \cdot \vec{v_1}, |\text{proj}_{\vec{v_1}} \vec{v_2} \cdot \vec{v_1}|)\vec{v_1} + \beta(\vec{v_2} - \text{proj}_{\vec{v_1}} \vec{v_2})$$

ResNet-18, trained for 200 epochs with SGD



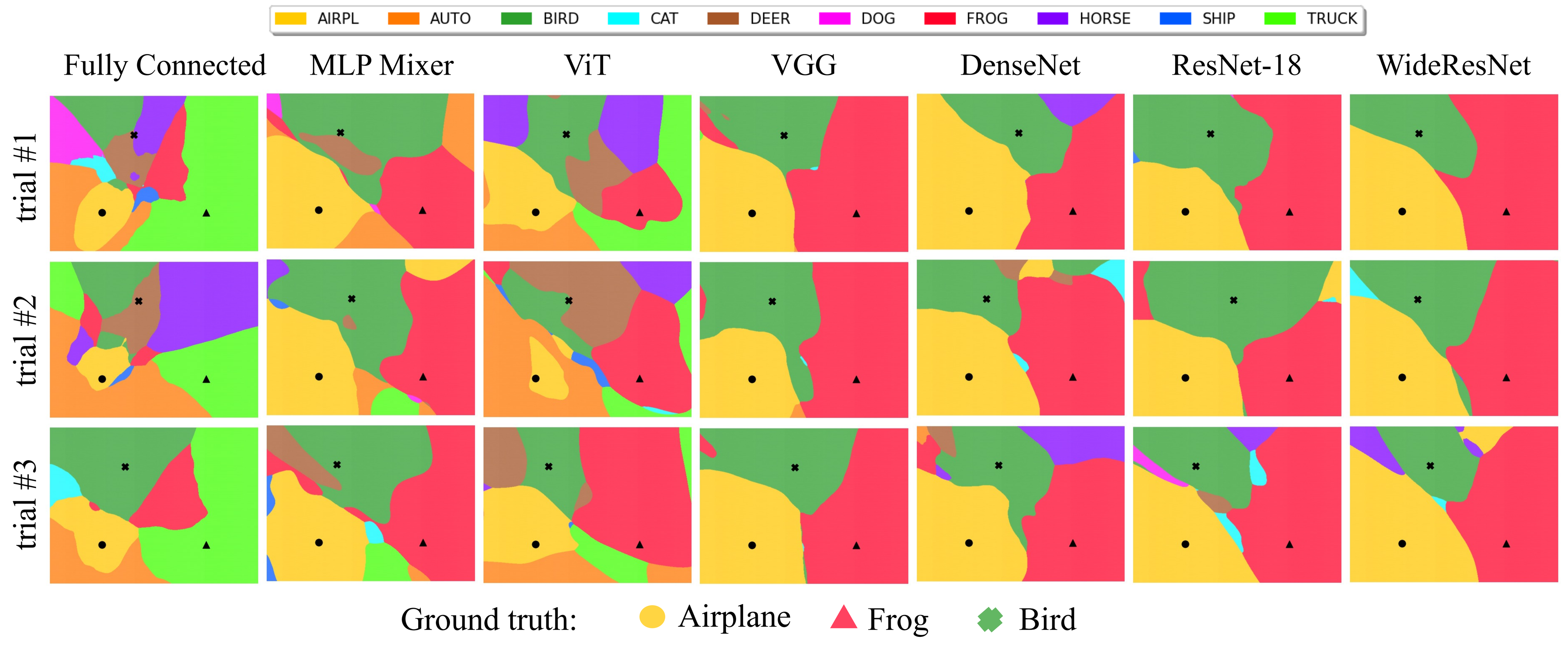


- The training process, which structures decision boundaries near the data manifold fails to produce strong structural effects far from the manifold.
- The uniform off-manifold behavior is an in- evitable consequence of the concentration of measures phenomenon

SCAN ME

Code and more materials available at https://somepago.github.io/dbviz

REPRODUCIBILITY



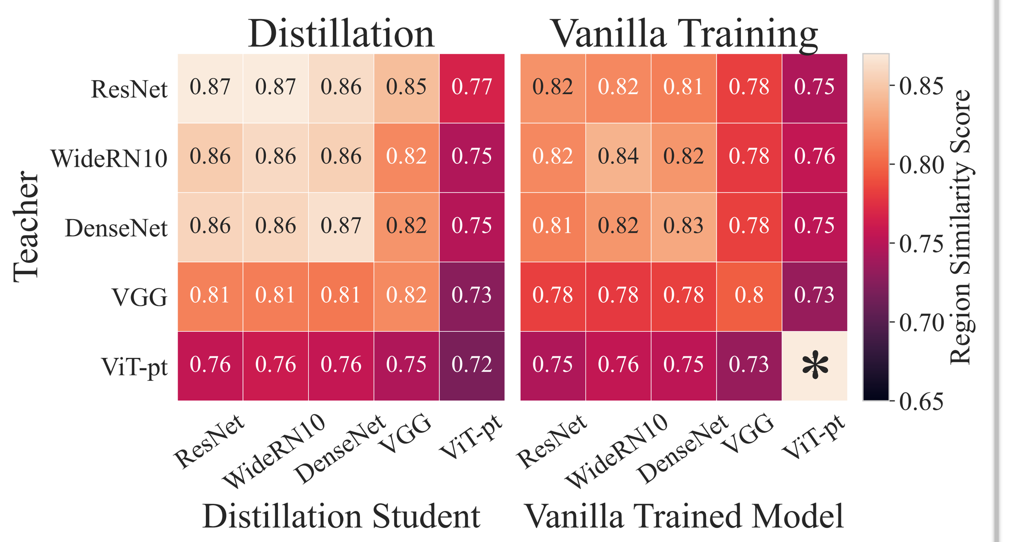
Region Similarity Score

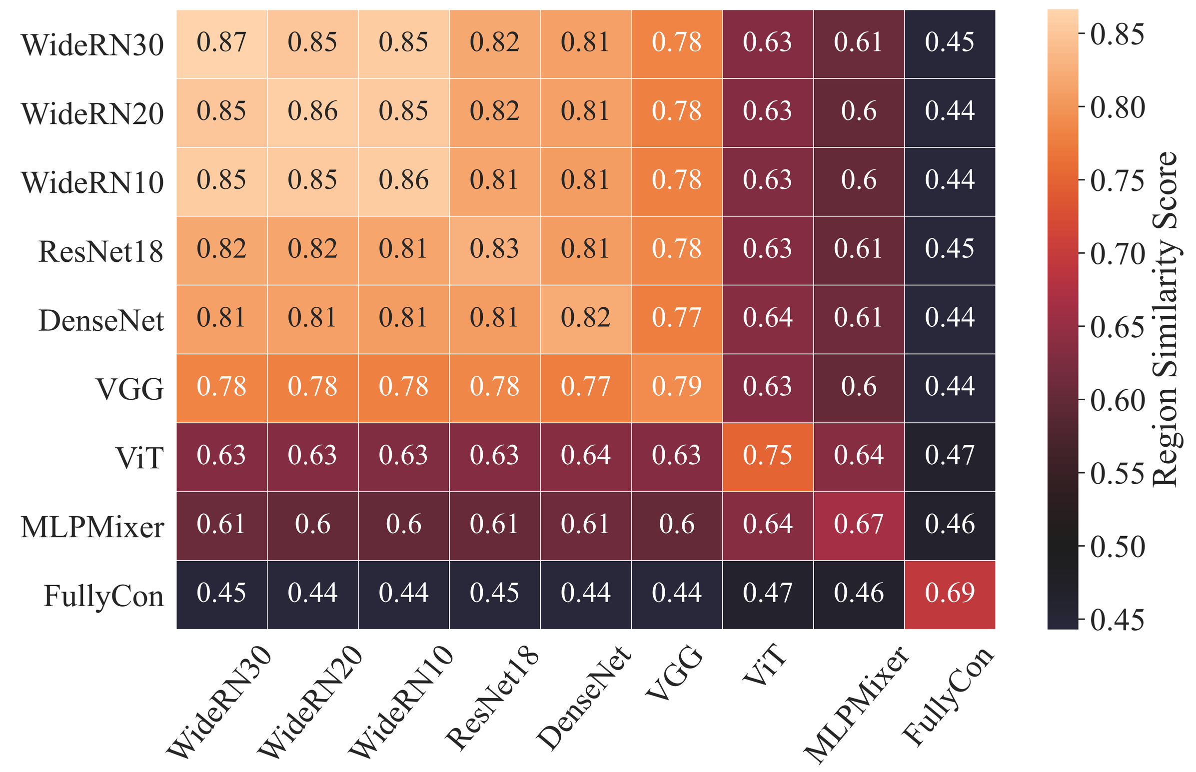
$$R(\theta_1, \theta_2) = \mathbb{E}_{T_i \sim \mathcal{D}}\left[(|f_{\theta_1}(S_i) \cap f_{\theta_2}(S_i)|)/|S_i|\right]$$

T_i Randomly chosen triplet

S_i Decision region spanned by T_i

$f_{\theta_1}, f_{\theta_2}$ Same architecture, trained differently





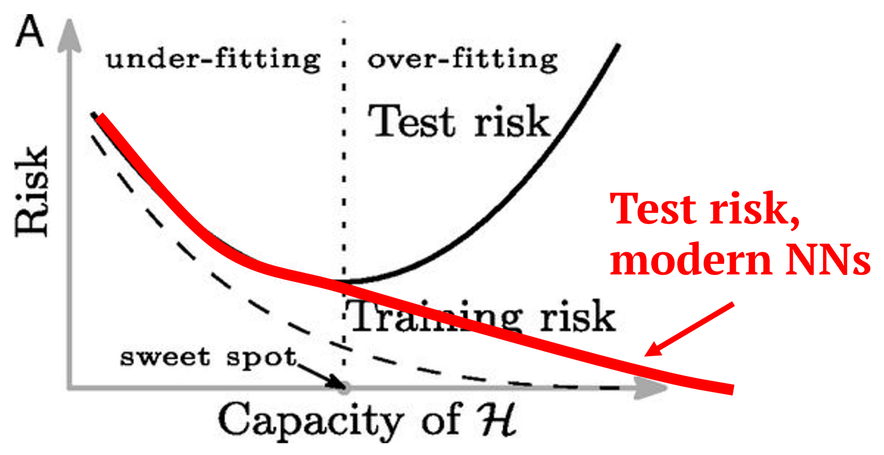
Region Similarity Scores

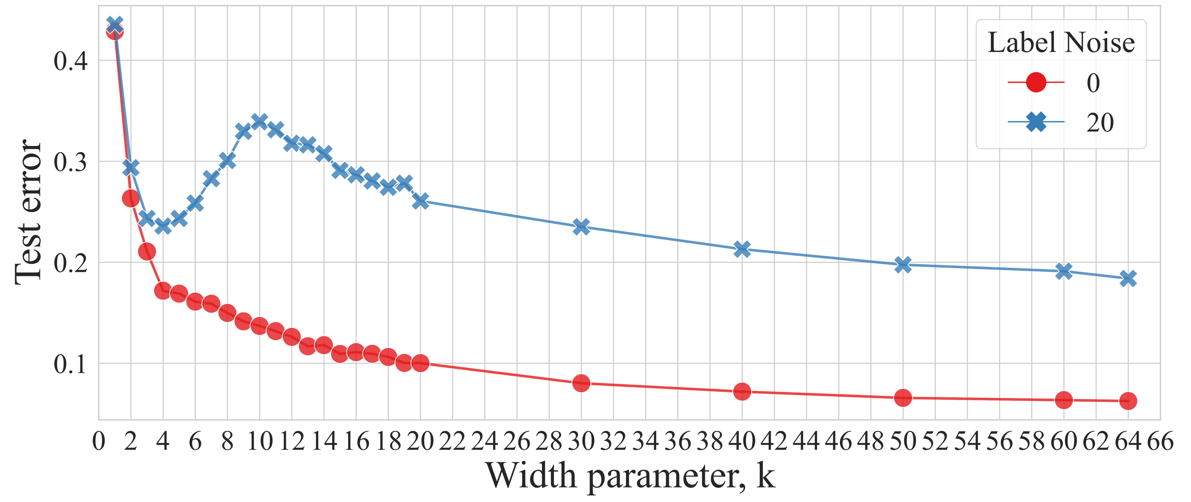
	Adam	SGD	SGD + SAM
ResNet-18	79.81	83.74	**87.22**
VGG	81.19	80.92	**84.21**
MLPMixer	67.80	66.51	**68.06**
VIT	69.55	75.13	**75.19**

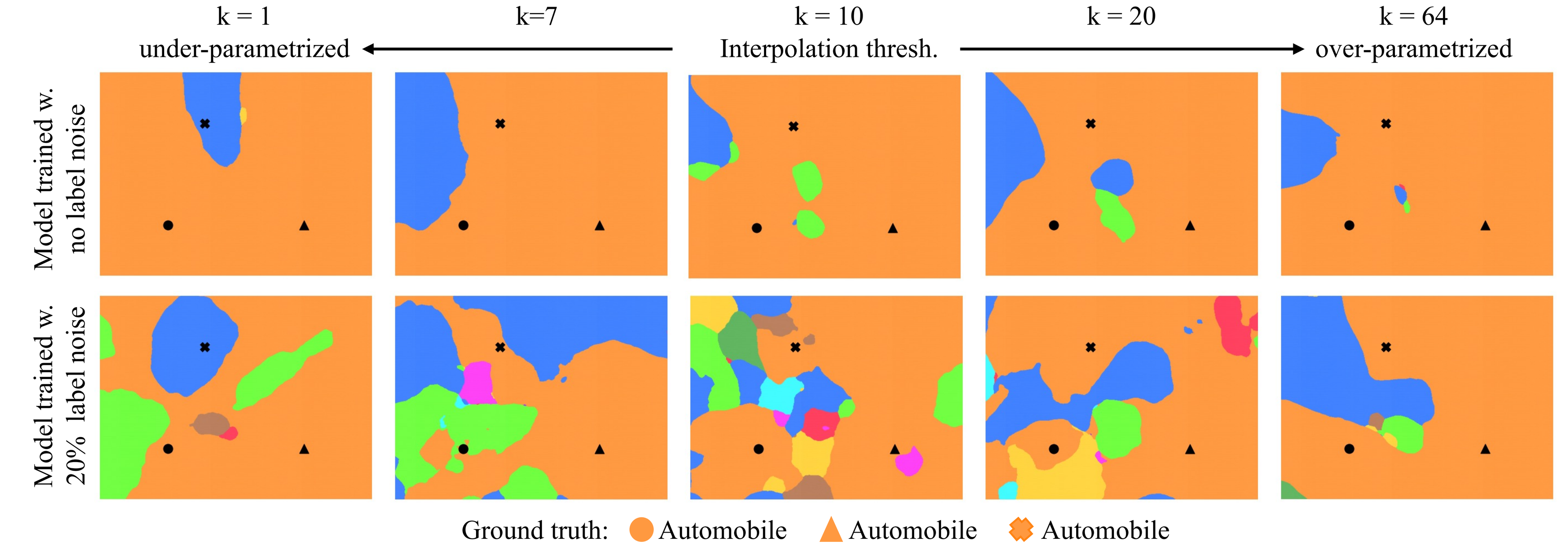
Test Accuracy

	Adam	SGD	SGD + SAM
ResNet-18	93.04	95.30	**95.68**
VGG	92.87	93.13	**93.90**
MLPMixer	**82.22**	82.04	82.18
VIT	70.89	**75.49**	74.72

DOUBLE DESCENT







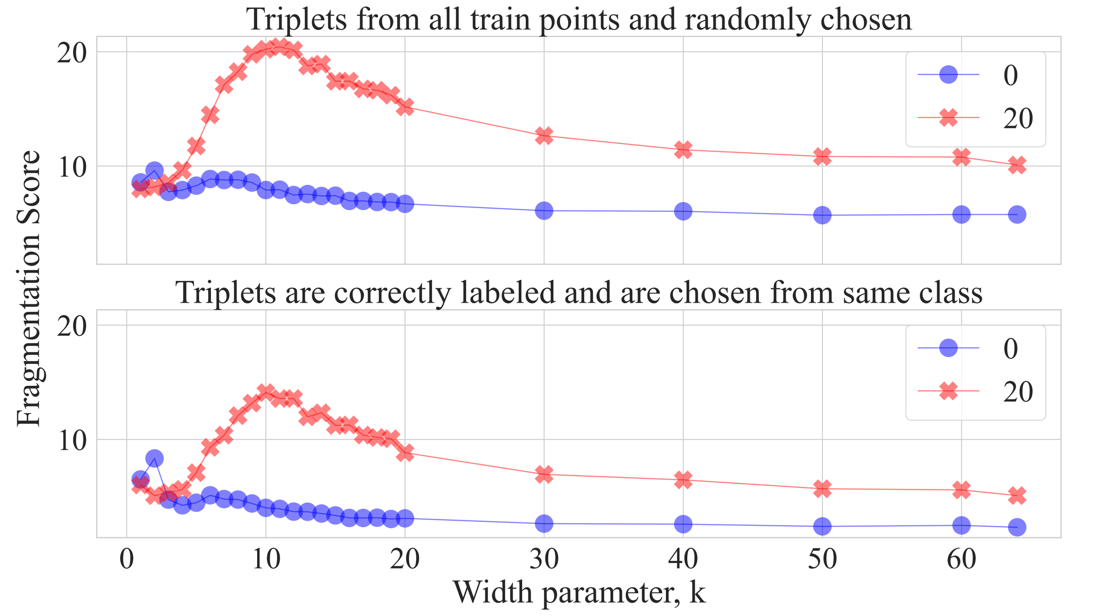
Fragmentation Score

$$S_i(\theta) = \cup_{j=1}^{n_i} P_j(\theta)$$

$$F(\theta) = \mathbb{E}_{T_i \sim \mathcal{D}}\, n_i(\theta, T_i)$$

T_i Randomly chosen triplet

$P_j(\theta)$ disjoint, maximal, path-connected component corresponding to a single predicted class label



The decision regions of models around double descent peak are more fragmented & less reproducible!