Model Zoology & Neural Taskonomy for Interpreting Mouse Visual Cortex

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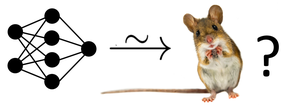
Motivation

Recent research has suggested mouse visual cortex is as well predicted by randomly-initialized neural networks as by trained ones…

Cadena & Co. (2019)



Is this true for only certain kinds of neural networks or for neural network modeling in mouse brains more generally?

Toolkit

6611 Neurons Responding to 119 Natural Scenes

ALLEN INSTITUTE for BRAIN SCIENCE

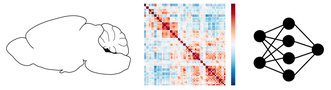
30 Models Trained on ImageNet with Different Architectures

PyTorch Model Zoo

24 Models Trained on Different Tasks with the Same Architecture

Taskonomy

1 Representational Similarity Analysis



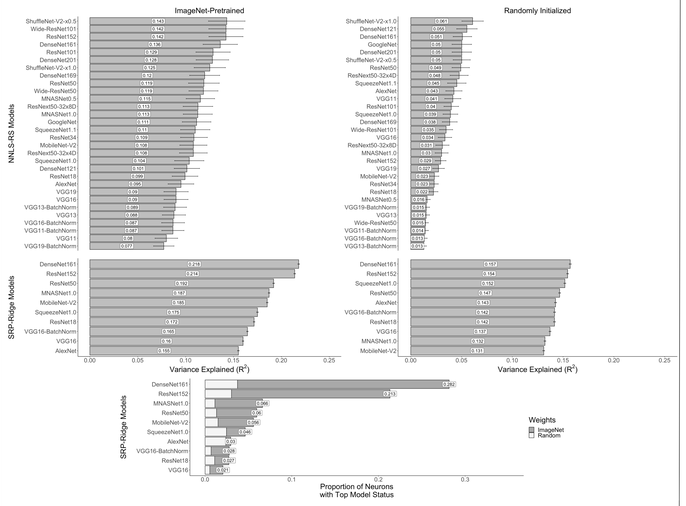
2 Neural Encoding Metrics

$= \beta_1$ + β_2

Model Zoology & Neural Taskonomy

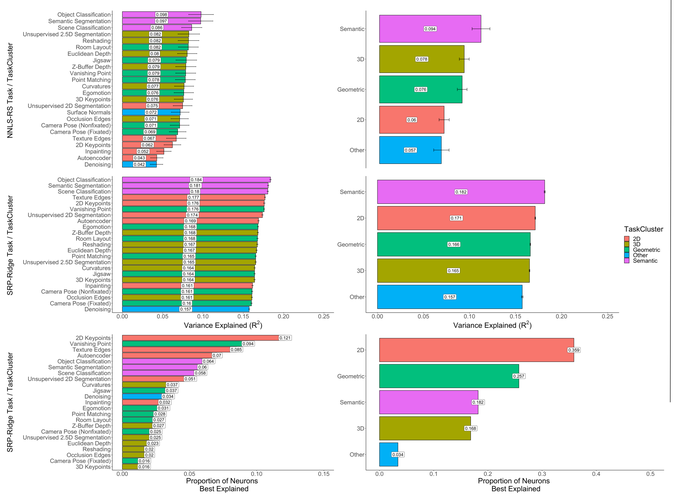
Model Zoology Rankings

How well do different architectures predict the brain?



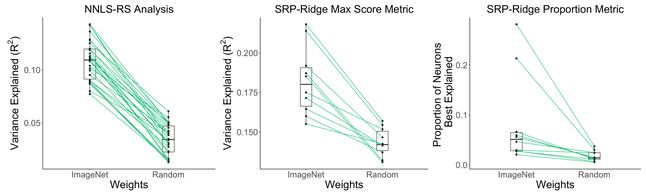
Neural Taskonomy Rankings

How well do different tasks predict the brain?



Trained versus Random Models

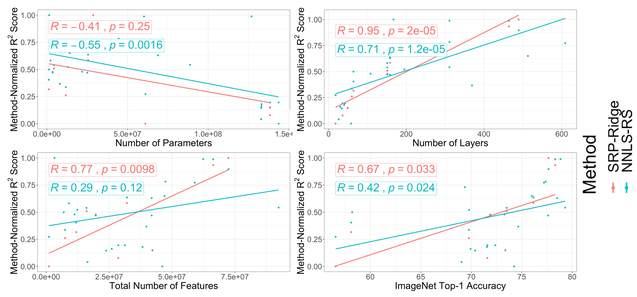
Does training a network give you better prediction?



ImageNet-Pretrained models categorically outperform their randomly initialized counterparts.

Properties of More Performant Models:

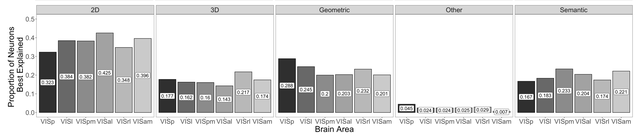
What design choices would lead to higher scores?



Deeper, thinner models with fewer parameters across larger numbers of activations are more predictive of the mouse brain.

Taskonomic Signatures

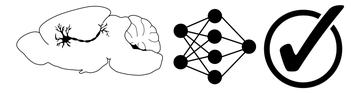
Do different tasks predict different parts of the brain?



There are significant taskonomic differences across cortical area, though the exact nature of these differences remains unclear.

Takeaway

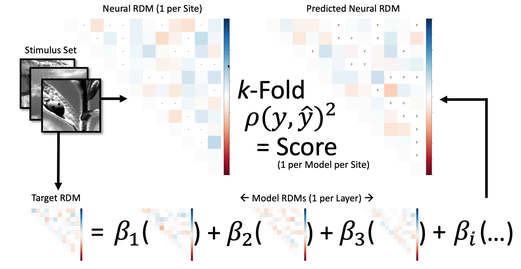
Trained models (no matter the task) do much better at predicting the mouse brain than randomly-initialized models…



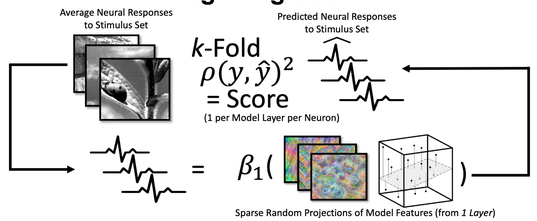
This makes mouse brains a valid target for neural network modeling, and a potentially rich source of insight for computational vision science moving forward.

Methods

NNLS-RS: Nonnegative Least Squares Representational Similarity



SRP-Ridge: Sparse Random Projection + Ridge Regression



Max Score Metric

The maximum score across layers of a given model for a given neuron, averaged across neurons.

Proportion Metric

The proportion of neurons for which the maximum score across across layers of a given model is the highest of any score for that particular neuron.