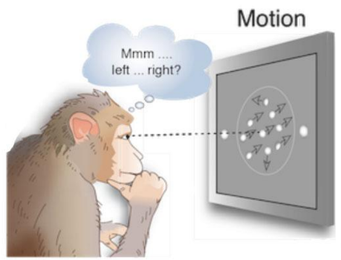
Applying 3D Deep Neural Networks to Human Psychophysics

Daniel Birman, Dylan Cable, Steeve Laquitaine

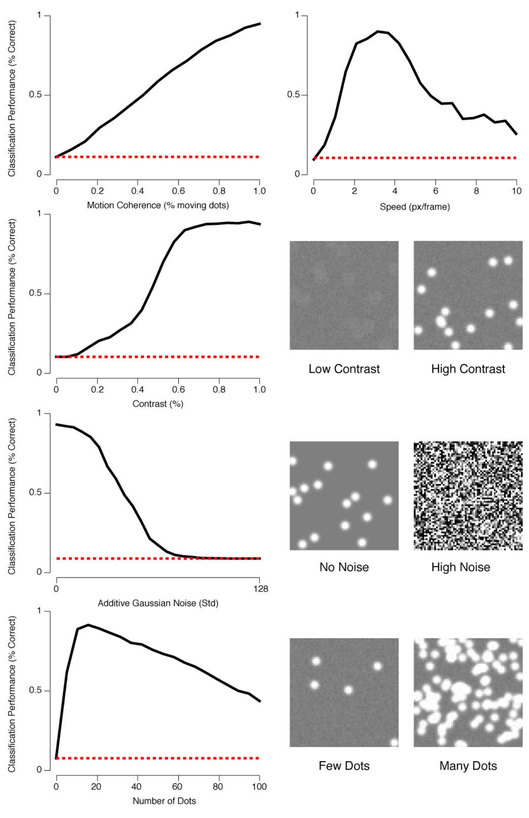
Stanford
Department of Psychology

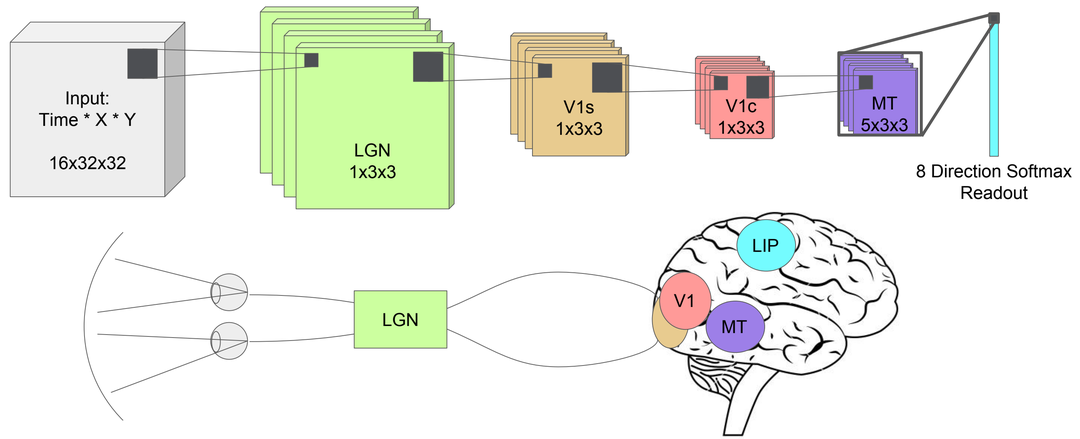
Motivation: Why Model Human Psychophysics?



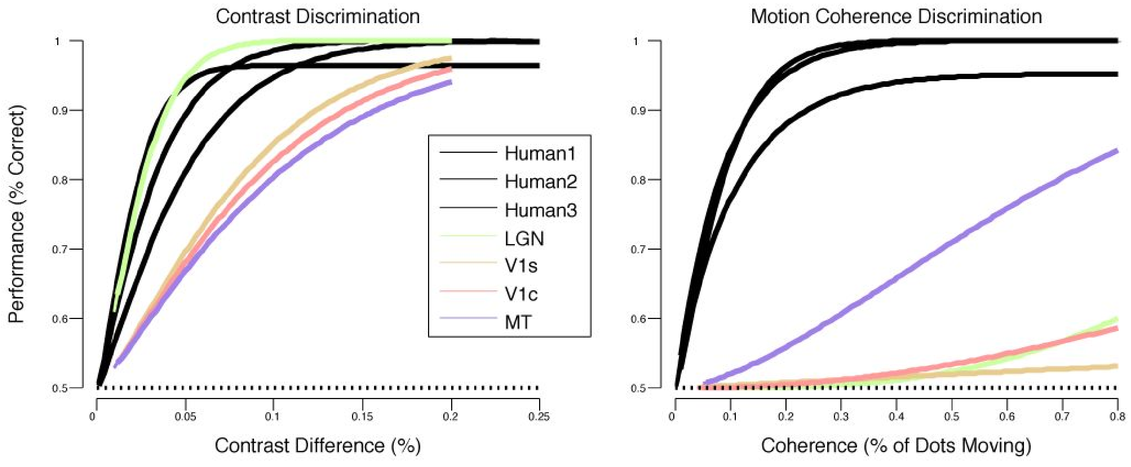
Computational models of the nervous system trained to **perform the same behavioral task** as humans can be used to help us understand human behavior (Yamins et al. *PNAS* 2014). We built a deep neural network modeled on the human visual stream and trained our model to complete a simple behavioral task: discriminate direction. Our model is a modernization of an older model without constraints on internal feature representations (Simoncelli et al. *PNAS* 1996).

Validation: Understanding our model



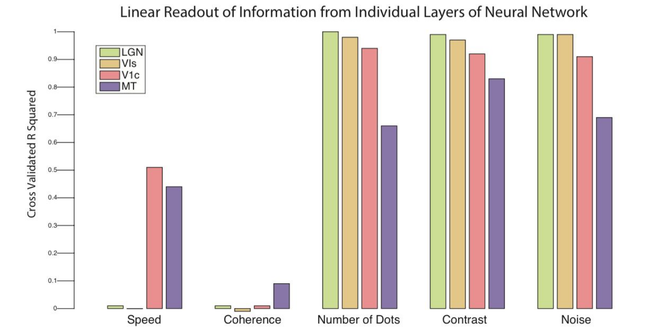


Humans vs. Machines: Comparing performance on a basic psychophysics task



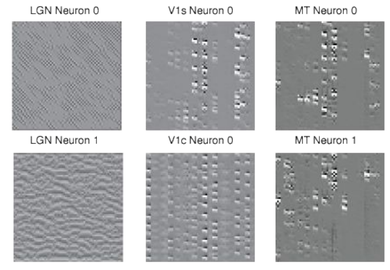
We compared our trained model on two basic psychophysics tasks to compare its performance with human behavior. We looked at **contrast discrimination** and **motion coherence discrimination**, two tasks that can be done on the random dot motion patches that we used to train our model (see our website for stimulus examples). Above we plot the amount of stimulus difference needed for humans to discriminate which of two patches of dots had higher contrast or greater motion coherence. We compare these results against a model-based linear readout from specific layers. We found that for contrast both human and model performance are qualitatively similar, while for motion coherence our model does not appear to capture the necessary features to linearly decode motion strength.

Readout: Does our model represent important motion features?



To understand the motion features represented by our model we computed regressions predicting each feature from layer outputs. To reduce dimensionality we averaged outputs across both space dimensions and time. We found that, although not explicitly trained for them, our model represented each of these features at particular layers.

Feature Inversion



Gardner Lab @Stanford University

Contact: dbirman@stanford.edu, dcable@stanford.edu, steeve@stanford.edu

http://gru.stanford.edu/doku.php/deepmotion