Comparison of generic convolutional networks versus biologically inspired networks as models of V4 neurons

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Introduction

- Area V4 is an intermediate visual area in the ventral visual pathway and this pathway is essential for object recognition
- Convolutional neural networks, such as VGG-16, have been used in computer vision to solve object recognition tasks
- VGG-16 features with linear masking can serve as a naive model for predicting V4 activity
- The Deep Convolutional Energy (DCE) model, as previously proposed by Oliver & Gallant 2017, consists of a cascade of learned spatiotemporal and spatial quadrature pair filters, mimicking the processing of the neural hierarchy up to V4
- Here we compared the DCE model, a biologically inspired model, with the VGG-16 Object Features model, a task-optimized convolutional network with pretrained weights

Data collection using naturalistic video stimuli

- Over 1 million naturalistic color frames were presented to awake, behaving macaques
- Data was recorded using 96 channel Utah arrays implanted in V4

DCE model outperforms VGG-16 Object Features model

- CCnorm is a normalized measure of the correlation coefficient between the prediction and the target V4 activity
- It takes into account Signal Power (SP), a noise ceiling computed across repeated trials (Rn)

\[
CC_{\text{norm}} = \frac{\text{Cov}(y, \hat{y})}{\sqrt{\text{Var}(y)SP}}
\]

\[
SP = \frac{\sum_{n=1}^{N} R_n}{N(N-1)}
\]

V4 Prediction Performance

Predict V4 activity using two neural network models

Comparison of VGG-16 Object Features model and DCE model in individual neurons

Conclusion

- DCE model outperforms the VGG-16 Object Features model on the V4 dataset
- Despite being trained on a different dataset, VGG-16 features are able to predict neural activity well

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