Deep Networks for Decoding Natural Images from Retinal Signals

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Presentation Abstract Summary Decoding sensory stimuli from neural signals can reveal how we sense our physical environment, and is critical for the design of brain-machine interfaces. However, existing linear techniques for neural decoding may not fully reveal or exploit the fidelity of the neural signal. Here we develop a new approximate Bayesian method for decoding natural images from the spiking activity of populations of retinal ganglion cells (RGCs). We sidestep known computational challenges with Bayesian inference by exploiting "amortized inference" via artificial neural networks developed for computer vision, which enables nonlinear decoding that incorporates natural scene statistics implicitly. We use a decoder architecture that first linearly reconstructs an image from RGC spikes, then applies a convolutional autoencoder to enhance the image. The resulting decoder, trained on natural images, significantly outperforms state-of-the-art linear decoding. Additionally, the decoder trained on natural images performs nearly as accurately on a subset of natural stimuli (faces) as a decoder trained specifically for the subset, a feature not observed with a linear decoder. These results provide a tool for the assessment and optimization of retinal prosthesis technologies, and reveal that the neural output of the retina may provide a more accurate representation of the visual scene than previously appreciated.

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