Video of moving discs reconstructed from rat retinal neuron signals

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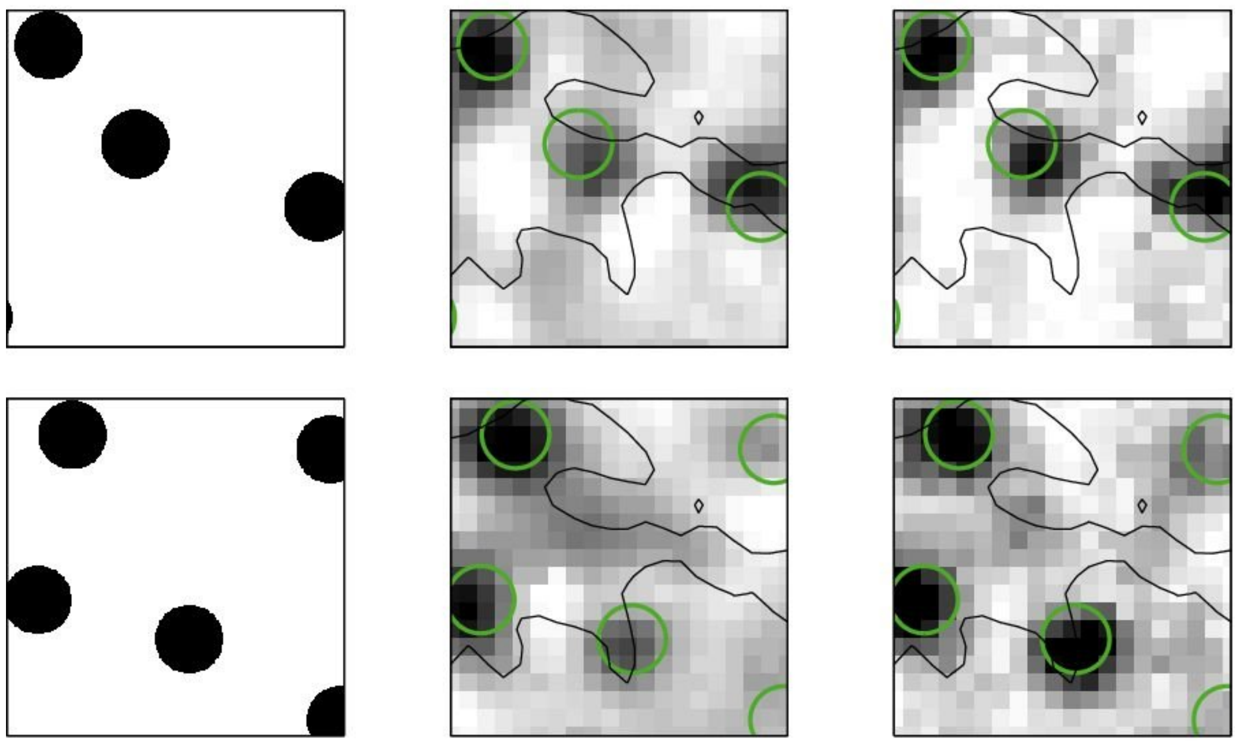

Reconstructing a video from the retinal activity. Left: two example stimulus frames displayed to the rat retina. Middle and right: Reconstructions obtained with two different methods (sparse linear decoding in the middle and nonlinear decoding on the right). Green circles denote true disc positions. Credit: Botella-Soler et al.

Using machine-learning techniques, a research team has reconstructed a short movie of small, randomly moving discs from signals produced by rat retinal neurons. Vicente Botella-Soler of the Institute of Science and Technology Austria and colleagues present this work in *PLOS Computational Biology*.

Neurons in the mammalian retina transform light patterns into electrical signals that are transmitted to the brain. Reconstructing light patterns from neuron signals, a process known as decoding, can help reveal what kind of information these signals carry. However, most decoding efforts to date have used simple stimuli and have relied on small numbers (fewer than 50) of retinal neurons.

In the new study, Botella-Soler and colleagues examined a small patch of about 100 neurons taken from the retina of a rat. They recorded the electrical signals produced by each neuron in response to short movies of small discs moving in a complex, random pattern. The researchers used various regression methods to compare their ability to reconstruct a movie one frame at a time, pixel by pixel.

The research team found that a mathematically simple linear decoder produced an accurate reconstruction of the movie. However, nonlinear methods reconstructed the movie more accurately, and two very different nonlinear methods, neural nets and kernelized decoders, performed similarly well.

Unlike linear decoders, the researchers demonstrated that nonlinear methods were sensitive to each neuron signal in the context of previous signals from the same neuron. The researchers hypothesized that this history dependence enabled the nonlinear decoders to ignore spontaneous neuron signals that do not correspond to an actual stimulus, while a linear decoder might "hallucinate" stimuli in response to such spontaneously generated neural activity.

These findings could pave the way to improved decoding methods and better understanding of what different types of retinal neurons do and why they are needed. As a next step, Botella-Soler and colleagues will investigate how well decoders trained on a new class of synthetic stimuli might generalize to both simpler as well as naturally complex stimuli.

"I hope that our work showcases that with sufficient attention to experimental design and computational exploration, it is possible to open the box of modern statistical and machine learning methods and actually interpret which features in the data give rise to their extra predictive power," says study senior author Gasper Tkacik. "This is the path to not only reporting better quantitative performance, but also extracting new insights and testable hypotheses about biological systems."

More information: Botella-Soler V, Deny S, Martius G, Marre O, Tkačik G (2018) Nonlinear decoding of a complex movie from the mammalian retina. *PLoS Comput Biol* 14(5): e1006057. doi.org/10.1371/journal.pcbi.1006057

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