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Beyond Linear Decomposition: Maximizing Information Transmission with Curved Manifolds TATYANA SHARPEE, Sloan-Swartz Center for Theoretical Neurobiology, University of California, San Francisco, WILLIAM BIALEK, Princeton University — We consider how to optimally separate multidimensional signals into two categories in order to maximize information transmission. Our motivation comes from the nervous system, where neurons process multidimensional signals into a binary sequence of responses (spikes). We derive a local equation for the decision boundary which relates the curvature of its contour, scaled by the noise level, to the probability distribution of input signals. In the case of correlated Gaussian inputs, straight lines are shown to provide optimal separation. For non-Gaussian inputs, however, the straight-line solution is not always optimal. For example, in the case of a 2D exponential probability distribution the exact solution for the optimal decision boundary is a hyperbola-type curve, and the angle between its asymptotes is fixed across nearly all spike probabilities. The ubiquity of non-Gaussian signals in nature, particularly the exponential distribution considered here, makes these results relevant for neurons across different sensory modalities. The predicted curvature of the optimal decision boundaries should be observable as sensitivity of neurons to multiple stimulus dimensions rather than just a single receptive field.

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