Psychophysics and computational models of behaviour

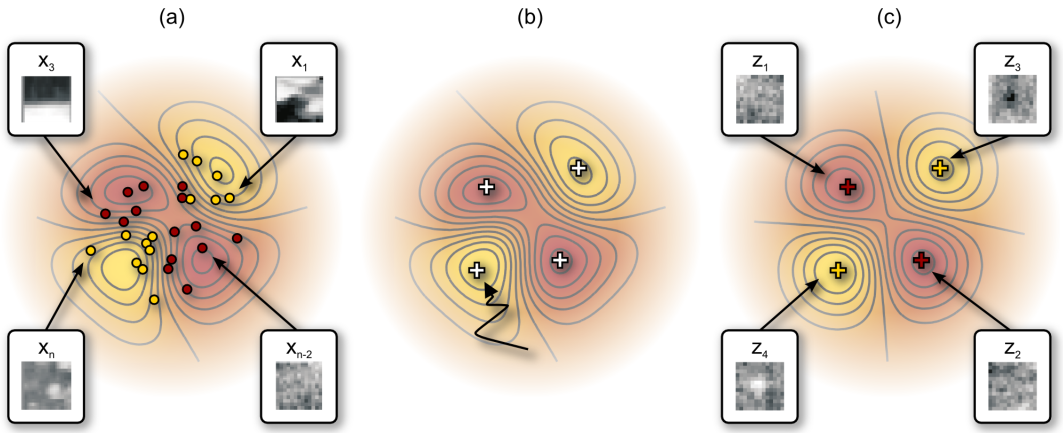

Figure 1.16: Visualization of the machine learning approach to uncover critical features. Consider the problem of predicting for an image patch whether it is likely to be a saccade target or not. Panel (a) depicts image patches that have (yellow) or have not (red) been saccade targets. The yellow-to-red gradient represent the response of a SVM with a Gaussian kernel trained on the patches. Panel (b): Gradient descent on the function that the SVM implements, extrema are indicated. Panel (c): Using the extrema, a network with four kernels centered on them approximates the SVM. (Adapted from [289].)

This project investigates human perception, combining psychophysical experiments and computational modeling. Currently we have four main research foci:

First, we develop methods to gain more information from psychophysical data. We characterized serial dependencies in behavioral responses, and introduced methods to correct for them [63]. We wrote a software package to perform Bayesian inference for the psychometric function for non-stationary data. In addition, we introduced the use of spatial point processes to characterize eye-movement fixation patterns [41, 99]. Finally, we continue to improve machine learning methods to uncover the critical features observers use in complex perceptual tasks [118, 148]) (c.f. [289] and Figure 1.16).

Our second focus is the development of an image-based model of spatial vision. We integrated the large psychophysical literature on simple detection and discrimination experiments and proposed a model based on maximum-likelihood decoding of a population of model neurons predicting several data sets simultaneously, using a single set of parameters [108].

Third, the project seeks to understand the fundamental questions of characterizing the computational principles underlying lightness perception, treating lightness perception as one example of how to rigorously study the visual mechanisms translating ambiguous retinal input into perceptually and psychologically relevant categories [22, 23, 117].

Finally, we are moving towards understanding perceptual causality. Recently there has been considerable progress in understanding causal inference by viewing it as a machine learning problem. This is relevant to perception since animals cannot operate based on the assumption of independent and identically distributed (iid) data but need to employ suitable inference methods that work under changing distributions in order to produce robust perception. We study causal models of perception in a simple binary classification setting where the perceiver needs to distinguish cause and effect, or forward and backward, a task we recently studied in a computer vision context [363]

More information: https://ei.is.tuebingen.mpg.de/project/psychophysics-and-computational-models-of-behaviour