Exact Bayesian Bin Classification: a fast alternative to Bayesian Classification and its application to neural response analysis

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We investigate the general problem of signal classification and, in particular, that of assigning stimulus labels to neural spike trains recorded from single cortical neurons. Finding efficient ways of classifying neural responses is especially important in experiments involving rapid presentation of stimuli.

We introduce a fast, exact alternative to Bayesian classification. Instead of estimating the class-conditional densities $p(x|y)$ (where x is a scalar function of the feature(s), y the class label) and converting them to $P(y|x)$ via Bayes' theorem, this probability is evaluated directly and without the need for approximations. This is achieved by integrating over all possible binnings of x with an upper limit on the number of bins. Computational time is quadratic in both the number of observed data points and the number of bins. The algorithm also allows for the computation of feedback signals, which can be used as input to subsequent stages of inference, e.g. neural network training.

Responses of single neurons from high-level visual cortex (area STSa) to rapid sequences of complex visual stimuli are analysed. Information latency and information response duration (IRD) increase nonlinearly with presentation duration, suggesting that neural processing speeds adapt to presentation speeds. Moreover, IRD is longer than presentation duration if the latter is smaller than ≈ 50ms, and shorter otherwise. Thus, for longer stimuli, the visual system should be able to separate the responses to successive stimuli, because IRD is the duration of the response needed for best stimulus discrimination. This is no longer the case for the shorter presentation durations: here responses to stimuli will begin to overlap, and thus optimal classification performance can no longer be attained.

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References
[1] The speed of sight. C. Keysers, D. Xiao, P. Földiák and D.I. Perrett, *Journal of Cognitive Neuroscience* 13(1):90-101, 2001.