Evaluating Bayesian model selection versus averaging, and alternative sensory likelihoods in cue combination

Rama Natarajan and Richard Zemel

Department of Computer Science, University of Toronto, Canada

A common hypothesis regarding how the brain integrates multi-sensory cues to generate a coherent percept is that the cues are combined linearly, weighted by their reliability. However, a potential form of non-linearity arises when the cues suggest very different estimates of a stimulus variable. The standard Bayesian approach that assumes independent and Gaussian noise in the cues, predicts that integrating the cues reduces the variance of the final estimate, which fails to fit the data under these circumstances. Following the intuition that multiple causal factors can give rise to a percept associated with the cues, recent modeling studies (Kording et. al., 2007; Sato et. al., 2007; Stocker & Simoncelli, 2008) have proposed a class of mixture models to evaluate sensory evidence simultaneously under multiple hypotheses. Employing one such causal generative model, we compare the explanatory power of Bayesian model selection and model averaging approaches in characterizing nonlinear cue combination in an auditory localization task (Wallace et. al., 2004). We find that model selection provides a better fit to the behavioral data. Within this framework, we also demonstrate that incorporating heavy-tailed sensory likelihooods rather than a Gaussian model produces a more accurate match to the data.