Decision-theoretic saliency: computational principles, biological plausibility and implications for neurophysiology and psychophysics

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A decision-theoretic formulation of visual saliency, first proposed for top-down processing (object recognition) in (Gao & Vasconcelos, 2005) is extended to the problem of bottom-up saliency. Under this formulation, optimality is defined in the minimum probability of error sense, under a constraint of computational parsimony. The saliency of the visual features at a given location of the visual field is defined as the power of those features to discriminate between the stimulus at the location and a *null* hypotheses. For bottom-up saliency, this is the set of visual features that surround the location under consideration. Discrimination is defined in an information-theoretic sense and the optimal saliency detector derived for a class of stimuli that complies with known statistical properties of natural images.

It is shown that the optimal detector consists of what is usually referred to as the standard architecture of V1 (Carandini, Demb, Mante, Tolhurst, Dan, Olshausen, et al., 2005): a cascade of linear filtering, divisive normalization, rectification and spatial pooling. The optimal detector is also shown to replicate the fundamental properties of the psychophysics of saliency (Treisman & Gelade, 1980): stimulus pop-out, saliency asymmetries for stimulus presence vs. absence, disregard of feature conjunctions, and Weber's law. Finally, it is shown that the optimal saliency architecture can be applied to the solution of generic inference problems. In particular, for the class stimuli studied, it performs the three fundamental operations of statistical inference: assessment of probabilities, implementation of Bayes decision rule, and feature selection.

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