Combining Multiple Cues for Contour Detection: Lessons from (and to) the Visual Cortex

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Object recognition depends heavily on shape information, and object shape is often primarily determined by contour structure. As such, reliable detection of shape-defining contours in complex scenes–that is, seeing the line drawing—is a visual computation of enormous scientific and practical importance. We have developed a neuromorphic architecture for shape-contour extraction, inspired by several features of visual cortex and informed by concepts from optimal probabilistic inference. The system combines 4 sources of information to estimate the probability of any given contour hypothesis. Two boosting influences arise from (1) long-range high-resolution contour structure in which learned prototypes are combined with a MAX-like operation, and (2) local coarsescale input, which modulates the contour hypothesis through a multiplicative factor. Two suppressive influences include (1) a measure of local edge density which acts through divisive normalization, and (2) spatial mutual exclusion effects, including cross-phase inhibition, which act via subtractive normalization. The network is highly effective at detecting well-organized contours in complex natural scenes. In this presentation, we discuss aspects of our approach that could help to explain several poorly understood features of visual cortical organization, including the existence of two distinct lateral inhibitory networks, multiple forms of synaptic temporal dynamics, and specific forms of nonlinear processing within the dendrites of visual cortical neurons.

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