Neural Computation of Statistical Image Properties in Peripheral Vision

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In the peripheral field of view our visual system provides a much lower image quality than in the central region. This has often been attributed to a mere loss of spatial acuity, but recent investigations suggest that the system uses a more refined strategy. For lowering its data load it computes a statistical summary representation based on low-level image features. In a recent modeling approach the summary statistics refer to classical statistical measures, like auto- and cross- correlations, operating on wavelet-like filter outputs.

Here we investigate how such a statistical representation can be obtained in a neurobiologically plausible fashion. For this, we consider both the elementary neural operations and the architectural properties. For example, the neurobiological plausibility of multiplications which are an essential component of classic statistical operations, is unclear and often critically debated. Also, it remains to be determined how the characterization of a statistical distribution, classically achived by moments or histograms, can be achieved by neurobiological hardware. Furthermore, it is unclear which specific visual features are actually best suited for an efficient statistical summary representation.

We address these problems by considering how basic neural nonlinearities, like cortical gain control, can contribute to the computation of statistical properties, how basic neural selectivities, e.g. for intrinsically two-dimensional signals are related to statistical features, and how results from the promising domain of deep learning can help to understand the role of architectural properties in a statistical representation. We show that the visual cortex can provide a reliable statistical characterization of the visual environment, and we discuss which role this representation can play for different visual tasks, e.g., for object recognition, gist estimation, and localization.

Keywords: peripheral vision, visual crowding, neuro-biologically motivated statistics, deep networks, image compression, localization