Complex scenes, simple neurons, and complex applications

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A great deal is known about the behaviour of the human visual system from both psycho-physical and physiological studies with simple stimuli such as gratings. However, the visual environment consists of complex scenes and often elicits complex actions. Can we use information gained about the behaviour of simple units in the visual pathway to say something about how we perceive complex scenes? If so, what novel applications exist that can make use of this knowledge?
We have been considering the issue of power spectra of natural scenes.We have shown (Parraga et al, 2000 Current Biology 10 pp35-38) that subtle shape discrimination tasks are optimised when image power spectra are `natural'. Furthermore, a simple model of contrast discrimination by cortical neurons predicts discrimination performance quite well. This model has been tested more extensively at a variety of eccentricities, and found to apply there as well. Such a model could form the basis for predicting the visibility of differences between pairs of images. This has applications in computer graphics, where considerations of power spectra are relatively novel. There is evidence that images with power spectra corresponding to those of real images are judged more `natural' than othersöthis has implications for generation of fractal terrains and texture mapping. Finally, we have recently shown that the spatial transfer characteristics of colour vision (which are probably mediated by single-opponent cells in the mammalian cortex) provide a close match to the properties of a subset of natural scenesöfruit on foliageöso the notion of optimisation to natural scene statistics may well apply in the chromatic domain as
well. This may provide a metric for assessing the utility of colour information in various kinds of display.