Modelling human discrimination of suprathreshold chromatic changes in natural scenes using a visual-cortex model

D.J. Tolhurst*, T. Troscianko†, P.G. Lovell†, I.D. Gilchrist† and M.To*
*Department of Physiology, Development & Neuroscience, Downing Street, Cambridge CB2 3EG, UK, and †Department of Experimental Psychology, 12a Priory Road, Bristol, BS8 1TU, UK

We are investigating how observers rate the magnitudes of spatiochromatic changes in images of natural scenes: e.g., changes in object position, shape or colour, and combinations of these. We rotate hue or change saturation of the whole image or of objects within it in an HSL space, reflecting discrimination or recognition tasks that observers meet in everyday life. The observers' task is to rate the perceived difference between images presented sequentially. We ask how well observers' ratings are predicted by modelling Gabor-like receptive fields whose linear and non-linear properties and interactions are based closely on human grating psychophysics and visual-cortex neurophysiology.

The first stage of the model splits each full-colour image into 3 colour planes; then the images are compared plane by plane, calculating the responses of nonlinear modelled simple cells selective to orientation and spatial frequency. The choice of the three planes is problematic, but we have had most success with a "Luminance" and two colour-opponent Boynton/MacLeod planes; the model is less predictive of human performance when we split as cone-based LMS planes or as machine-based RGB planes. When the three channels are matched for the sensitivity to luminance and isoluminant RG or BY gratings (from Mullen & Kingdom, 2002, Vis.Neurosci., 19, 109), the three channels contribute roughly equal weight to the predictions. The model output is a single number that estimates how big a difference observers would perceive between image pairs. The model works as well for colour changes as for shape/size changes, even with peripherally-viewed stimuli where the RG system is very much less sensitive.

Some kinds of image change, for example blur, texture and object disappearance (but not chromatic ones), are badly predicted by the cortex-based model. This may point to limitations of low-level models in accounting for globally-perceived image characteristics.

Supported by EPSRC/Dstl JGS grant S56399 and S56405.