Integration of different features in guiding eye-movements

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Introduction

In natural behaviour we actively attend to parts of a visual scene by moving our eyes. Models of such attentional behaviour combine different local visual features in a bottom-up process to derive salient locations (e.g. Itti & Koch, 2001; Perhoniemi & Nõndro, 2002). Here, we developed a Bayesian, datadriven model of saliency and studied the feature integration process empirically. We investigated the interaction of luminance, luminance contrast, texture contrast, edges and colour contrast during free viewing of natural stimuli.

We develop an eye-tracking data-driven Bayesian measure of saliency and study:

1) How does the saliency of a feature vary in the context of a second feature?
2) How does the saliency of a feature vary in the context of a second feature?

We model this feature interaction with additive and multiplicative integration processes.

Methods

We analysed eye-tracking data from free viewing baseline conditions of two studies. In a grayscale data set was taken from Acik et al. (2017b) and contained 64 images in 4 categories (natural images, scenes and objects, close-up faces, and fractals). Natural images were taken from the “Zurich Natural Image Database” (http://www.kbl.caltech.edu/~weiz/ ZurichNatDB.tar.gz). A colour set contained free-viewing data of 96 colour-calibrated images from the Kibale rainforest in Uganda (courtesy of Prof. Tom Troscianko, University of Bristol).

We generated feature maps for mean luminance (L), luminance contrast (LC), luminance contrast on low-pass filtered images (LCLP), texture contrast (TC), edges (Bar), red-green contrast (RG) and yellow-blue contrast (YB) at spatial scales of 1, 2 and 5 degrees according to the respective measures used in Einhäuser & König (2003). Colour contrasts follow the definition of LCLP, applied to the respective channel in the DKL colour space (Darrington, 1984).

We quantify the interaction of features in measured saliency distributions with mutual information. We use multiple regression to reconstruct the measured joint salience model with additive and multiplicative combination of the individual salience distributions for the two features.

Results

1) Some features contribute linearly and others non-linearly to a joint saliency map.

2) Individual features contribute independently to salience. Integration of features can be explained by additive integration. However, multiplicative models had a similar fit to the data.

Discussion

We used a Bayesian measure of saliency to study the interaction of two features in eye-tracking data during free-viewing of different image categories. We model the integration of two features in saliency with additive and multiplicative integration processes.

We find that: (1) features contribute to salience in linear and nonlinear ways. And (2) in general knowing the value of one feature does not give much information about the salience of another feature. That is, different features contribute independently to a joint saliency map. Additive integration of individual saliencies gives a good description of the data for most analysed image combinations within and across feature channels. However, multiplicative interaction explained the data equally well in most cases. In summary, we argue that selection of salient regions can be explained by independent processing of individual features that are additively combined.

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