The multidimensional perceptual space of local orientation signals
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Motivation and Overview

The orientation cues present in natural scenes are much richer than the orientation cues that are present in the simple grating and line stimuli typically used to study how orientation is processed. One aspect of this richness is that multiple orientations can occur at a single location. Another is that orientation cues can arise not only from positive correlations, but also from negative ones. A third is that the correlations that carry orientation information need not be limited to pairwise correlations; third- (and higher) order correlations can also be oriented.

to determine whether the human visual system makes use of this rich set of cues, and if so, how they interact, we constructed a set of visual stimuli (binary textures) in which each of these different kinds of cues can be introduced independently and in combinations. The results show that human observers make use of multiple kinds of orientation cues, and that they interact in a relatively simple fashion.

Methods

The diagram on the right shows all 10 coordinates of the texture space. Of these, the first four second-order coordinates (the betas) and the four third-order coordinates (the thetas) are potential carriers of orientation information. We focus on these.

Coordinantes for a Local Binary Texture Space

Textures are defined by the distribution of colors of 2x2 blocks. There are 16 (2^4) possible colorings (light, black, or both) of such blocks. A coordinate value of 0 corresponds to a random texture. This ratio, the "pooling index", is 1 if image statistics are processed independently, and π if they are pooled.

Fourth order correlations are divided into individual terms and did not depend on target location.

Poolng Index

$\text{Pooling Index} = \frac{\sum_{i} \sum_{j} \text{corr}(\theta_i, \theta_j)}{\sum_{i} \sum_{j} \text{corr}(\beta_i, \beta_j)}$


Summary and Conclusions

In addition to the standard orientation cues present in gratings (cues carried by pairwise correlations), third-order correlations also provide salient orientation cues. Both kinds of cues can occur at the same location, and with positive and negative signs.

Second- and third-order orientation cues are processed largely independently of each other, and the way that they are processed differs in two ways:

a. Pooling across orientations is more extensive for third-order cues than for second-order cues.

b. Dependence on global organization (i.e., whether signals arise in the foreground vs. the background) is characteristic of third-order but not second-order cues.

Superimposed on this picture, corners played a special role: when combinations of second-order orientation cues produced corners, these combinations provided a stronger signal for texture segregation than expected from their components.

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