Differences in processing of low- and high-order image statistics revealed by classification images extracted via regularized regression

**INTRODUCTION**

The luminance histogram and spatial correlations are two kinds of image statistics that are known to play important roles in texture segregation. In most psychophysical studies, one of these kinds of statistics is manipulated, while the other is kept constant. For example, in 2D texture studies (Chubb et al. 1994), each 2D texture’s luminance is independently chosen from a specified distribution, thus manipulating the luminance histogram, while keeping spatial correlations constant (Pollen et al. 1978). High-order spatial correlations are manipulated while keeping luminance and second-order statistics constant.

Maximum-entropy extension (Zhu et al., 1998) provides a means to generate textures in which luminance histograms and spatial correlations are simultaneously manipulated in a controlled fashion. We recently studied a two-parameter family of textures generated by this approach (Victor et al. 2005). We found that within this family, luminance and spatial correlation cues are processed independently (upper right corner of matrix).

We then applied the method of classification images (CI’s) to gain insight into the computations underlying perceptual decisions (Ahumada & Lovelace, 1971). In the usual approach to extract classification images (Coxeinen & Ahumada 2002), the mean stimulus associated with each perceptual decision is compared. We added two analytical ingredients. First, to identify nonlinear contributions, CI analysis was based on “derived images” (obtained by applying a local nonlinearity to each stimulus on the stimulus display, random target on the stimulus display, and target on the stimulus display). Second, we used regularized regression to recover detail that might be overlooked by standard subtraction.

**METHODS**

**TASK:** Identify the location of the target stripe (4-AFC, top, right, bottom, left)

**SUBJECTS:** N=5, VA corrected to 20/20; practiced for 2-3 hrs

**STIMULI:** 116 deg square, viewed binocularly at 57 cm, contrast 1.0, luminance 57 cd/m², duration 200 ms, reftest 75 Hz (Dal Tornion Morsion)

**CONDITIONS:** Feedback on error in all practice and experimental blocks, 288 trials per block (8 repeats of coordinate-axis points and 16 repeats of diagonal points randomized in every block, 15 such blocks/subject), 4320 trials/subject

**CLASSIFICATION IMAGE ANALYSIS AND RESULTS**

Derived images are constructed by:
- Local estimation of the statistics of interest
- Optional contrast inversion, so that target is brighter than background
- Construction of derived images
- Stimuli
- Optional contrast inversion

For each kind of derived image (γ and ρ), classification images were computed by several methods.

**REFERENCES**


Lam, C. M. (1999) Psychophysical performance followed a Weibull function in the two-dimensional space, and a Minimum rule adequately described how sensitivity in the oblique directions depended on sensitivity in the cardinal directions. That is, the observed fraction correct data was well-described by a Weibull function with

**CONCLUSIONS**

• The classification image method can be extended to a strongly nonlinear context via the use of “derived” images.

• Regularized regression can identify details in a classification images overlooked by standard subtraction analysis.

• Statistics near a putative border play a disproportionate role in texture segregation, as might be expected from edge-enhancing mechanisms at lateral inhibition.

• Spatial weighting of luminance statistics shows greater edge-enhancement than spatial weighting of fourth-order statistics in 3 of 5 subjects, and on average.