Conclusions

Until 500 ms

Gaussian Derivative Model

Yaniv Morgenstern, James H. Elder, & Yuqian Hou
Centre for Vision Research, York University, Toronto, Ontario

Purpose

Detection of low-contrast luminance-defined stimuli can involve spatial summation over a large portion of the visual field. However, prior psychophysical results suggest that the summation region may shrink substantially in the presence of high-contrast masking gratings or noise (Legge & Foley, 1996; Kapadia et al., 1999). This may be related to recent findings that the extent of spatial summation in V1 neurons depends upon contrast (Sceniak et al., 1999; Kiper & Ohzawa, 1999).

Here we use a classification image technique to directly test whether the psychophysical receptive field for a simple stimulus (a vertical edge in noise) is dependent upon contrast.

Methods

Stimulus

• 256×256 binarized monochrome image
• Mean luminance = 49.7 cd/m²
• 1 pixel = 0.2 arcmin
• Vertical luminance step edge within a Gaussian window of diameter 2σ = 13 deg
• Left side of edge always darker than right
• IID additive 0-mean Gaussian noise

Design

• 3 observers: 1 author and 2 naive
• Single-interval yes/no task with feedback
• 10 blocks of 500 trials per condition for each observer
• Randomized block design over 3 levels of noise contrast (4.3, 14.8, 50.0%)
• QUEST (Watson & Pelli, 1983) used to adapt edge contrast to maintain performance near 75% correct.

Procedure

• Trial sequence: fixation → blank screen → edge + noise OR noise alone
• Observer indicated presence or absence of the edge by pressing 1 of 2 keys.

Analysis

• Maximum likelihood fits of a first-derivative of Gaussian model to the classification image data were computed.
• 68% confidence intervals on the 3 model parameters were estimated by bootstrapping.
• X-Y separability of the model was exploited to compute 1D X and Y projections of the classification image data.

Receptive field model: \( r(x, y) = x \exp(-x^2/2\sigma^2) \cdot \exp(-(y-y_0)^2/2\sigma^2) \)

Results: Example Subject

Noise Contrast = 4.3%

Results: Grouped Data

Noise Contrast = 4.3%

Results: Summary

Complete horizontal fits

Conclusions

1. Edge detection summation fields are well-approximated by a first derivative of Gaussian model.
2. Summation fields were found to expand by a factor of 2 to 3 with increasing noise contrast. This expansion appears to be primarily across the edges, not along the edge.
3. These results run counter to prior physiological and psychophysical data suggesting a contraction of receptive field size with increasing contrast.
4. Summation fields were generally found to be displaced toward the lower hemifield, particularly at higher contrasts.

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