Orientation Integration in Complex Visual Processing

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Introduction

• A new object recognition paradigm allows investigation of orientation-defined features relevant to object perception using natural stimuli.

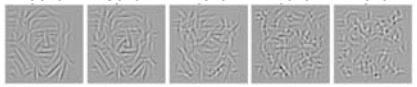
•Sensitivity to collinear or orthogonal orientation information can be tested by manipulating properties of elements that are chosen to represent the object image and noise.

Methods

•Images are composed of a large set of Gabor wavelets whose properties are derived from local image statistics
•Gabors can be placed either in true location (signal element) or in random location (noise element)
• Coherence thresholds are obtained by measuring minimum number of signal elements required for object identification

Proportion of signal elements:

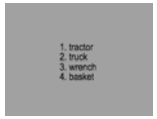
100% 80% 40% 20% 0%



Procedure

Object Image

List of Categories



Object Recognition Paradigm:

• Image is selected at random from a list of 40 object categories with 5 exemplars of each object, and presented for 1s. Proportion of signal elements in correct location is varied by a staircase procedure.

• Following image, subject is presented with a choice of four candidate categories and selects which category the object belongs to.

• Coherence thresholds identified as minimum proportion of signal elements required for 75% correct identification.

Are Edges or Corners Differentially Important for Object Identification?

EDGES

•Computational models of natural images suggest that edge detectors may be optimal for efficient coding. (Bell & Sejnowskii, 1997)

CORNERS

•Junctions and corners may be used to define and identify an object. (Biederman, 1987)

Manipulating Orientation Variance of Signal Element Pairs:

• Compute difference in orientation between adjacent element pairs.

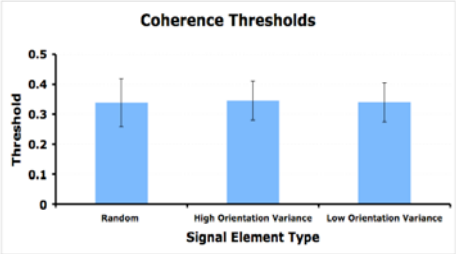
• Order elements according to orientation difference, select elements starting from high or low end of distribution.

• Signal elements can be pairs of elements closest to one another that are either similar in orientation (edges) or orthogonal (corners), or contain random orientation difference.

RESULTS:

• No difference in coherence thresholds for different orientation-variance element pairs.

• Object recognition appears to be based on global processing of image, rather than on bottom-up identification of salient local features

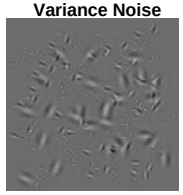


Manipulating Orientation Difference of Noise Element Pairs:

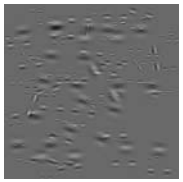
• Noise consists of element pairs with either high or low orientation difference, forming noise consisting of edges or junctions.

• Signal elements consist of randomly selected singlets derived from object image.

High Orientation Variance Noise



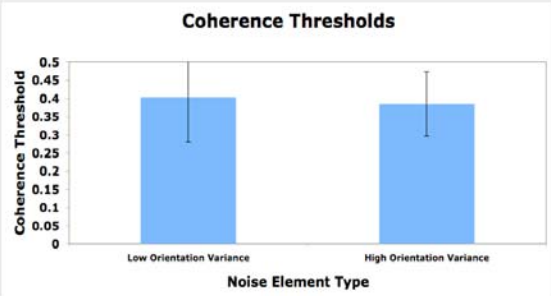
Low Orientation Variance Noise



RESULTS:

•High and low orientation difference elements do not differentially decrease task performance, confirming global image processing over local feature identification.

•Visual system discounts orientation of noise during object recognition



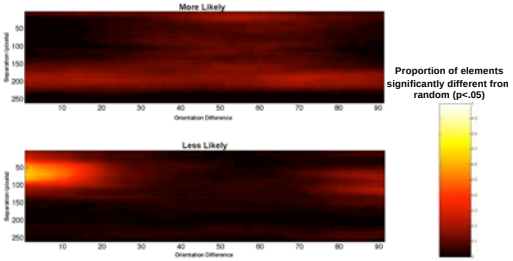
What signal elements are present on correct trials?

• Analyze orientation and distance difference between element pairs, calculate which orientation/separation element pairings were present on correct trials.

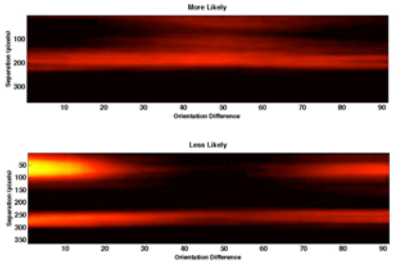
•Compare to shuffled experimental data to determine which pairings are more or less likely to occur than chance.

•Plot distribution of significant changes in orientation difference and separation on correct trials.

High Orientation Difference Noise:



Low Orientation Difference Noise:



• High or low orientation variance pairs are unlikely to appear in signal elements on correct trials

•Subjects do not use different strategies in the presence of high or low orientation variance noise

Conclusions

• New object recognition paradigm allows manipulation of local orientation information for real-life object recognition problems.

•Object recognition seems to take place with top-down, global identification process rather than by bottom-up local feature detection process: performance does not depend on proportion of edges/corners, nor on presence of edge/corner distractors.

REFERENCES:

Bell, A. J. and Sejnowski, T. J. (1997). The 'independent components' of natural scenes are edge filters. Vision Research, 37(23) 3327-3338.
Biederman, I. (1987). Recognition-by-Components: a theory of human image understanding. Psychological Review, 94(2),115-147.
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