Detection of Occluding Targets Across the Visual Field

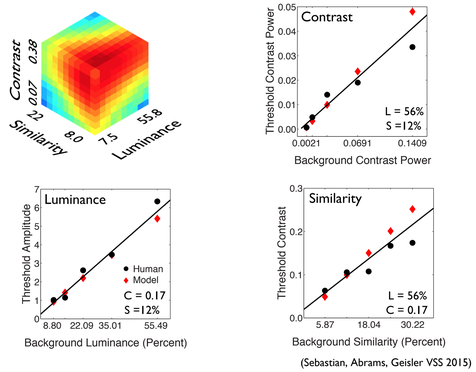
Stephen Sebastian, R. Calen Walshe, & Wilson Geisler

Center for Perceptual Systems, University of Texas at Austin

Motivation

Several factors affect detection thresholds for spatial targets in natural backgrounds

Previous experiments have identified some of these factors with additive targets:



(Sebastian, Abrams, Geisler VSS 2015)

Weber's law for **luminance**

Weber's law for **contrast power**

Weber's law for **spatial similarity**

Objects in nature occlude backgrounds

Goal: Measure masking laws for occluding targets across the visual field

Outline

Collect natural images to use as stimuli

Measure local image statistics

Bin along statistical dimensions

Sample from bins in experiment

Measure performance across the visual field

Natural Scene Statistics

1,200 natural images from the Austin area

Divide into millions of 0.35°x0.35° patches

Compute statistics for each patch under target envelope

$B(x,y)$ Image patch

$T(x,y)$ Target 

$env(x,y)$ Target envelope $\sum env(x,y) = 1$

Luminance (%max monitor luminance)

$$L(x,y) = env(x,y) \bullet B(x,y)$$

Contrast (RMS contrast)

$$C(x,y) = \left\| \frac{B(x,y) - L(x,y)}{L(x,y)} \sqrt{env(x,y)} \right\|$$

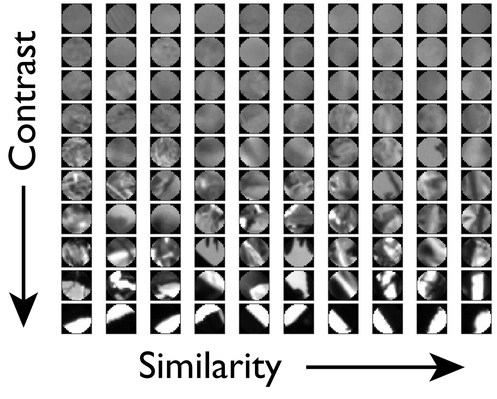
Similarity

Frequency and orientation similarity

$$S(x,y) = \frac{A_T(u,v) \bullet A_B(u,v)}{\|A_T\| \|A_B\|}$$

Example patches with a fixed luminance

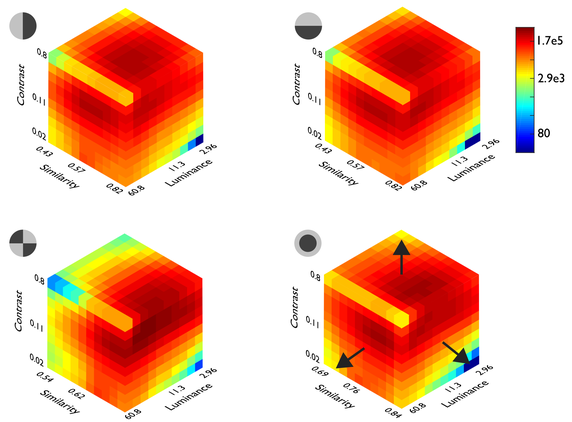
$T(x,y) =$ 



Constrained Scene Sampling

Sort patches into 1000 3D bins

Joint distribution of statistics for each target



Sample from these bins in experiment

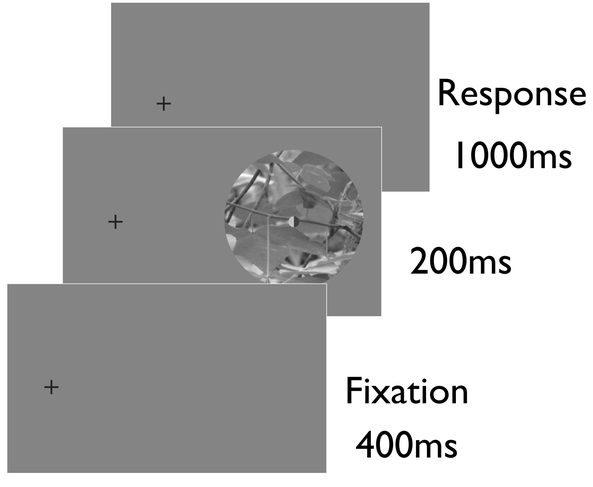
Experiment

Fix target contrast (0.33) and mean luminance (18.3)

Block by fixation location, L, C, and S

Occlude background w/ target on signal trials

Vary fixation location to measure threshold

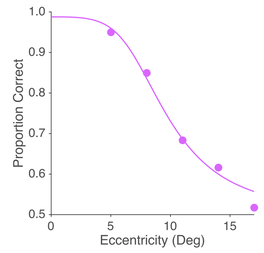


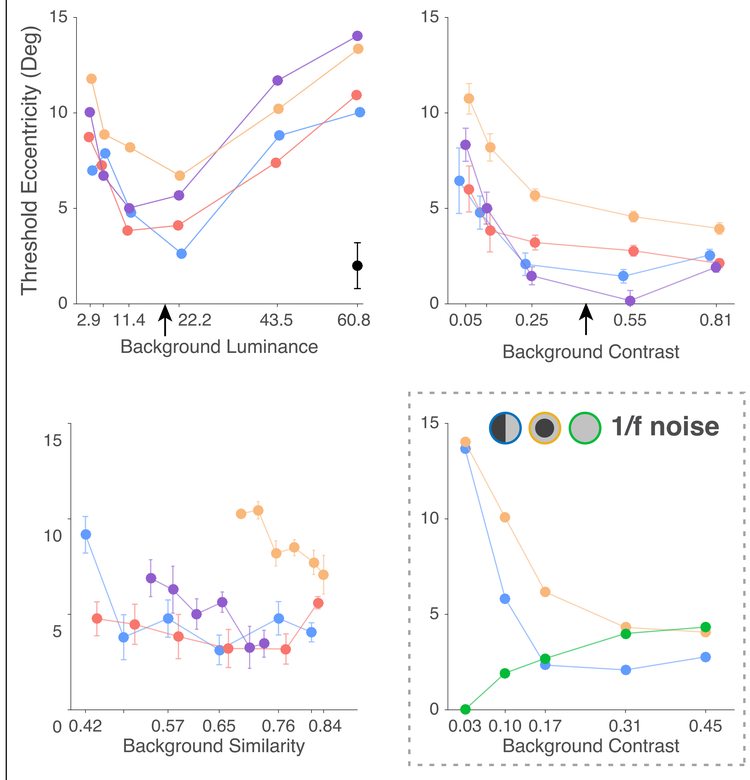
Results

Eccentricity psychometric functions

$d' = 1$ at threshold

Higher threshold corresponds to better performance





Developed approach for measuring occluding target thresholds in natural images

Performance decreases as background statstics approach target statistics

Threshold functions consistent across subjects

Future work: develop generalized match template model

Supported by EY11747