Contour Integration Using Boundary and Region Information

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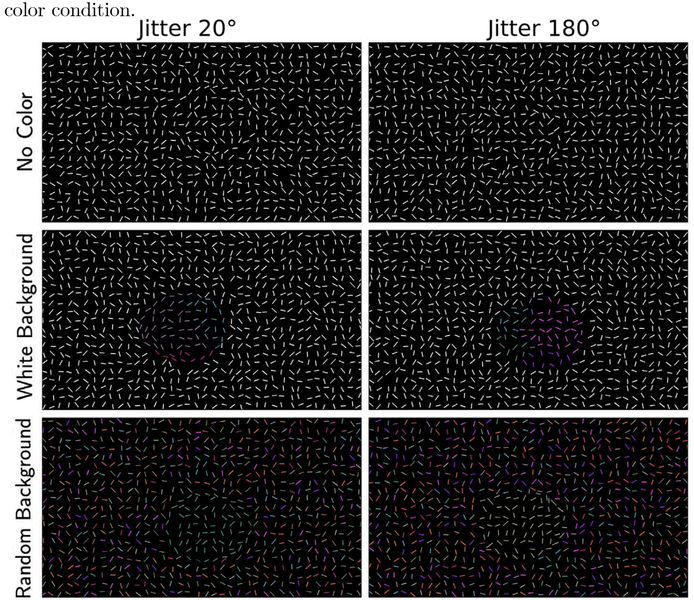
Introduction

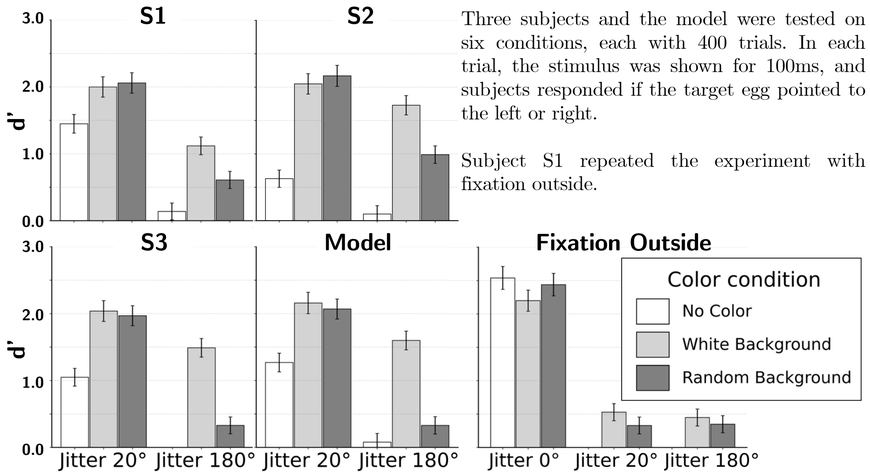
1. We studied the interaction between boundary (edge) and region (color) information in human boundary extraction
2. A computational model successfully emulated human performance by solving the problem in the log-polar representation, which approximates the retinotopic mapping in the primary visual areas of the brain
3. The shortest path in log-polar representation implements four Gestalt grouping principles: proximity, good continuation, convexity and closure

Stimuli

Jitter 20° eliminated local collinearity cue; jitter 180° randomized orientations of boundary edges. Improvement in performance due to color was measured by comparing performance in the white or random background conditions with the no color condition.



Results



Three subjects and the model were tested on six conditions, each with 400 trials. In each trial, the stimulus was shown for 100ms, and subjects responded if the target egg pointed to the left or right.

Subject S1 repeated the experiment with fixation outside.

Summary

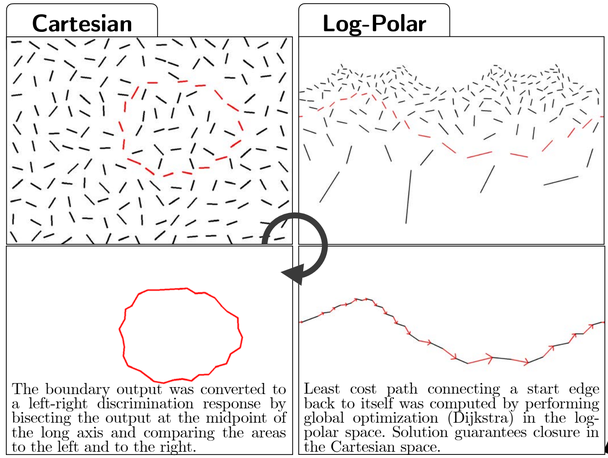
Psychophysical Experiment	• Performance was highest with contour and color combined • Interaction between contour and color: Consistent background color improved performance only when contour information was unreliable • No interaction was found when fixating outside
Computational Model	• Using four parameters, the model emulated subjects' performance on all conditions • When tested with real images, the model produced reasonable outputs with only contour information. Adding color information further improved performance

References

Kwon, T., Agrawal, K., Li, Y., & Pizlo, Z. (2016). Spatially-global integration of closed, fragmented contours by finding the shortest-path in a log-polar representation. *Vision research*, 126, 143-163.

Schwartz, E. L. (1977). Spatial mapping in the primate sensory projection: analytic structure and relevance to perception. *Biological cybernetics*, 25 (4), 181–194.

Computationl Model

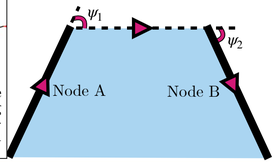


The boundary output was converted to a left-right discrimination response by bisecting the output at the midpoint of the long axis and comparing the areas to the left and to the right.

Least cost path connecting a start edge back to itself was computed by performing global optimization (Dijkstra) in the log-polar space. Solution guarantees closure in the Cartesian space.

Graph-based global optimization with four parameters in the cost function:

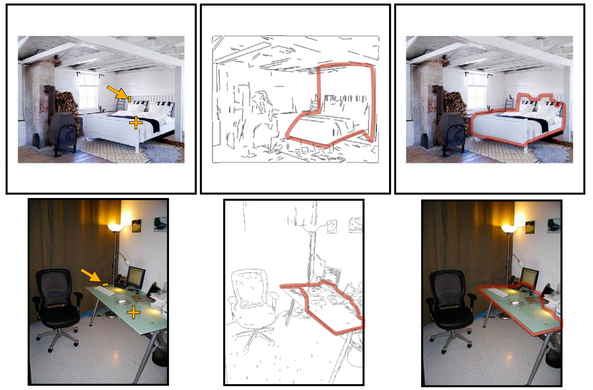
- Distance
- Angle ψ_1, ψ_2
- Color consistency
- Color contrast



Real Images

Examples where the model performance improved when the model utilized color information in addition to contour. Fixation point was placed inside the object, and a randomly selected starting edge belonging to the target boundary was given.

Left: Input images from Pix3D
Middle: Outputs of model without considering color
Right: Outputs of model combining contour and color



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