Attention to Objects and Perceptual Organization

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OBJECTIVE

Information overload impacts technological and biological systems. Example: Surveillance (but really *anything*)

Solution: Selective attention, i.e. sequential selection and processing of the most relevant information only

Our approach: Use mechanisms of perceptual organization to structure sensory input and guide attention according to primate neural representations

Different from other attentional approaches: organize sensory scene not by spatial relationships (pixels) but by perceptual (proto-)objects
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*Sparsity (in space and time!)*

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Classical approach: Saliency map

Saliency Map

Winner-Take-All

Inhibition of Return

Center-Surround Feature Maps

Early Vision Feature Maps

Color

Intensity

Orientation

Visual Scene
Saliency map is predictive of eye movements

Parkhurst et al, Vision Research 2002
Interest Maps

Conscious selection of “5 most interesting points”
15 images from database of 100 natural scenes
874 participants

Interest is highly correlated with fixations and with saliency map

Maschiochi et al, J. Vision 2009
“Tap at the first location you look at!”

Minimize top-down influences

Jeck et al, Vision Research 2017
Result: Taps are highly significantly correlated with
- Fixations
- Interest
- Computational Saliency

Jeck et al, Vision Research
Saliency map: Limitations

Very successful but

• Fundamental elements are 'pixels' (~RGC activity) while biological attention operates on perceptual objects

How do we add the notion of objects?

Not trivial!
Neuronal representation of image context in visual cortex
Border Ownership Coding In Primate Extrastriate Cortex

Receptive Fields in V2 are Small

Contrast invariance, size-invariance

Access to a Variety of Cues

Consistent results are obtained with different features: contrast, outline figures, disparity, ...

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Response Latency

Zhou et al. 2000
Border ownership is mutually exclusive
Model Design Considerations

• Edges of objects may be owned on either of their two sides

• Border ownership cells respond preferentially for a single side of ownership

• Border ownership cells have broad access to image context with short, fixed latencies (this rules out models based on horizontal connections)

• Determination of border ownership occurs independently of high-level functions such as object recognition
Model Architecture

Grouping Cells: Multi-scale annulus-shaped receptive fields provide proximity grouping and convexity preference

fuzziness = robustness
Model Results: Size Invariance

Cell 13id4 (V2)

Model
Model Results: Consistency Across Shapes