Visual attention

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Outline

1. What is attention?
   - Definition
   - Types of attention

2. Deployments of attention
   - Binding through attention
   - Perception of Meaning and Gist

3. Bottom-Up Attention
   - Saliency Map
   - Object recognition through selective visual attention

4. Top-Down Attention
   - Action Oriented Human Vision

5. Summary
William James, in *Principles of Psychology* (1890):

"Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which in French is called distraction, and Zerstreutheit in German."
Model for the evaluation of attention in patients with very different neurologic pathologies (Sohlberg and Mateer, 1989):

- Focused Attention
- Sustained Attention
- Selective Attention
- Alternating Attention, Divided Attention
- Overt/ Covert Attention
- Bottom Up/ Top Down
Anne Treisman in *How the deployment of attention determines what we see* (2006):

"Attention is a tool to adapt what we see to our current needs."

Binding features through attention:

- We must shift the attention window in space to select one object after another.
- We must exclude or suppress features of other objects, to prevent illusory conjunctions.
- Finally we must bind the selected features together.
Binding through attention

**Figure:** Attention focused on one object
Binding through attention

Figure: Attention spread over three items (binding failures)
Perception of Meaning and Gist

Figure: Divided attention - Statistical processing mode
Perception of Meaning and Gist

**Figure:** Focused/distributed attention - judgment of the mean size and size of an individual post-cued circle
Top-Down/Bottom-Up Attention

- Only a small fraction of the information registered by the visual system influences behaviour.

- Attention selects information relevant to behaviour priorities and objectives.

- Two component framework:
  - top-down: 'spotlight of attention' under cognitive, volitional control
  - bottom-up: based on the saliency of the stimuly
A saliency-based search mechanism for overt and covert shifts of visual attention (Itti and Koch, 1999)

**Figure:** Leon Bibel, Farm Scene, 1938
A saliency-based search mechanism for overt and covert shifts of visual attention (Itti and Koch, 1999)

**Figure:** Schematic diagram of the model from Itti and Koch
**Figure:** (a) Gaussian pixel widths for the nine scales used in the model; center/surround differences (b) Spatial competition for salience implemented within each of the 42 feature maps
**Figure:** Iterative spatial competition for salience in a single feature map
Figure: Example of working model with inhibition of return mechanism
What is attention?

Deployments of attention

Bottom-Up Attention

Top-Down Attention

Summary

Figure: Model performance on noisy versions of pop-out and conjunctive tasks
Selective visual attention enables learning and recognition of multiple objects in cluttered scenes (Walther, 2005)

Figure: The process flow in multi-object recognition experiments
What is attention?

Deployments of attention

Bottom-Up Attention

Top-Down Attention

Summary

Figure: Learning and recognition of two objects in cluttered scenes
**Figure:** (A) 6 of the 21 objects used in the experiment; (B) The ratio between object area vs. image area varies between 5% and 0.05%
**Figure:** Recognition without attention/with attention/by human subject
Modeling Attention with Embodied Visual Behaviors (Sprague, 2005)

**Figure:** The Walter simulation. Three of Walter’s microbehaviours: (a) collision avoidance; (b) sidewalk navigation; (c) litter collection
Figure: The Visual Routines that compute state information
What is attention?

Deployments of attention

Bottom-Up Attention

Top-Down Attention

Summary

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Immediate Reward</th>
</tr>
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<tbody>
<tr>
<td>Picked up a litter can</td>
<td>2</td>
</tr>
<tr>
<td>On sidewalk</td>
<td>1</td>
</tr>
<tr>
<td>Collision free</td>
<td>4</td>
</tr>
</tbody>
</table>

Table II. Walter’s reward schedule

Figure: Q-values and policies for the three microbehaviour
Modelling attention with Embodied

**Figure:** Model and human subjects’ fractional gaze allocation
Attention:

- **Focused vs. Distributed**
  - binding features
  - extracting meaning and gist

- **Top Down vs. Bottom Up**
  - task dependent
  - saliency based
Thank you for your attention!