The Visual System: Visual Perception

The problem of perception

Where an object is? Where it is going? What it is? How do we recognize an object?

Perception of 3-D space

Perceiving 2-D objects is fairly simple because 2-D visual images are already constructed at the level of the retina. The non-trivial 3-D perception that we experience everyday results, however, from our visual system's use of *depth cues*.

Because the position of the eyes and the shape of the lens are correlated with the distance of the objects we see, *convergence* and *accommodation* act as oculomotor cues for depth.

Because we see the world with two eyes that provide us with slightly different views, *retinal image disparity* is a binocular cue for depth. Some neurons in the visual cortex are able to detect retinal disparity and act as *depth detectors.*

Monocular or *pictorial cues* for depth perception also exist: interposition, linear perspective, relative size, texture gradients, shading.

Our constant moving through space provides an additional source of visual information about the 3-D spatial arrangement of objects around us. Whenever we move, the images projected by objects located at different distances move across our retina with different speed, creating distinct patterns of motion in the retinal images (*motion parallax*, *optic flow*).

Perception of Movement

Our perception of movement arises from the motion of images across the retina as detected by visual neurons that either simply sensitive to motion or specifically selective to the direction of motion of visual stimuli. These neurons act as *motion detectors*.

Nevertheless, motion can be perceived even when there is no motion of an image across the retina. Appropriately timed change in position is sufficient for the visual system to make something appear as moving. Visual neurons detecting real motion are also sensitive to apparent motion.

We not only detect motion, we also interpret it. The elements surrounding an object influence and can even induce the perceived motion of this object. The perceptual system is at all times confronted by the *correspondence problem*, i.e., determining which elements of the current view corresponds with which elements in the previous view.

Perception of Form

According to the Gestalt school of psychology, a form is not perceived by somehow summing up all its individual components, but by considering is as a coherent, intact *Gestalt*[1], a whole that is different from the sum of its parts.

The processing steps in perceiving a visual scene are:
1) The detection of its features,
2) The parsing of the scene so that figures can be identified from the background, and
3) The grouping of the figures' parts into single objects.
4) The recognition of the forms or patterns.

The perception of form begins with the detection of *primitive features*: color, orientation, etc.

The *visual segregation* process asks: What goes with what? What is focal? The perceiver contributes all aspect of perceptual segregation; it is not a property of the stimulus itself.

The *perceptual organization* of the elements within a visual scene is guided by some factors described by *Gestalt* psychology as principles: prägnanz[2], proximity, similarity, good continuation, closure, common fate, familiarity. The Gestalt principles of perceptual grouping can be united under a single general rule: the principle of maximum likelihood.

Pattern recognition involves both *bottom-up* and *top-down* processes, i.e., processes that are respectively dictated by the incoming stimulus information (data-driven) and influenced by one's expectations and beliefs (knowledge-driven).

The process underlying the recognition of the vast variety of 3-D objects that surround us involve some analysis levels concerned with objects parts. Some *geometric primitives* (*Geons*) substitute the feature primitives in the recognition of more complex patterns.

The structural description of an object (the representation of the object's 3-D geometry provided by *Geons*) and the meaning of that object can be dissociated, as demonstrated by patients suffering from *visual agnosia*.

Visual perception is an active process that involves the successive *testing* (consciously or unconsciously) of *hypotheses*. Overt perceptual problem solving, as well as everyday perception, seem to be governed by a series of logical principles:
1) The solution must provide a coherent explanation for all the information contained within the visual scene.
2) It must avoid contradiction.
3) It must avoid interpretations of the world that are unlikely.

When logic fails, impossible figures can be perceived…

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[1] *"Entire figure"*
[2] *"Goodness of form"*